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EDITORIAL.

ITEMS AND NOVELTIES.

Louisville Bridge.—The bridge to span the Ohio River at Louisville, Ky., is being rapidly pushed to completion, and is now so far advanced that the engineers are confident that trains will cross early in November next. The first stone on this bridge was laid August 1st, 1867, since which time the work has steadily progressed. There are 27 piers and 4 abutments (including 2 abutments at crossing of Jeffersonville and New Albany Railroad) containing in the aggregate 31,000 cubic yards of stone. This masonry supports an all-iron superstructure having a total length of 5,280 feet, and composed of spans varying in length from 50 to 400 feet, these are arranged in the following order, commencing at the Kentucky end, viz: two spans of 50 feet, one draw span over Louisville and Portland Canal of 264 feet, four spans of 150 feet, two spans of

180 feet, two spans of 210 feet, two spans of 227 feet, one span of 370 feet (over grade), six spans of 245·5 feet, one span of 400 feet, (over grade), three spans of 180 feet, one span of 150 feet, and one span of 100 feet reaching Indiana abutment, also one span of 49 feet in continuation of embankment over Jeffersonville and N. A. R. R.

The grade of rail approaching the bridge on Kentucky side is elevated four feet above that at point of crossing on High Street, from which street it ascends at the rate of 76 feet per mile, striking the first span of bridge at an elevation of 61 feet above low water, and continuing the same till it reaches the Kentucky end of the 370 feet span over the middle channel, where it has an elevation of 95 feet above low water in this channel. From this point the grade is level to the Indiana end of the 400 feet span, which spans the Indiana Channel (a distance of 2,243 feet) at this point. The grade line is 101½ feet above low water (low water mark being 6½ feet lower than in middle channel). The grade from here descends at the rate of 76 feet to the mile, reaching the northern abutment 35 feet above surface of ground; the grade of Indiana approach continues to descend at same rate, reaching the surface at a distance of 2,500 feet from abutment.

The superstructure is placed below grade except where it crosses the Middle and Indiana Channels.

All of the piers are finished but four, and these are so well advanced that they will be finished before required for the superstructure. This is being raised at both ends; on the Kentucky side the 370 feet span has just been completed, and one of the intermediate 245·5 feet spans is being erected, on the Indiana side the 400 feet span is in process of erection.

The undergrade portion is of the plan known as Fink's Suspension Truss, while the channel spans are of the triangular plan as arranged by the same gentleman, the 370 feet span is the longest iron truss yet erected in America, and is of wrought iron, excepting the top chords and brace pedestals, they being of cast iron. The braces and posts are of Phœnix wrought iron columns varying in diameter from 5 to 17 inches, according to the position they occupy in the structure.

The 400 feet span is entirely similar in detail and arrangement. The undergrade portion has its top chords, floor-beams (arched, with a tie), and post pedestals of cast iron, the remaining parts are of wrought iron, the posts being of Phœnix columns.

This bridge will be arranged for the accommodation of both railroad and carriage traffic, with a foot-walk on either side, all on the same floor. The railroad track will be laid in the centre with an outside rail on either side, one rail of the railroad track forming with each outside rail a double street railroad track.

No street cars or vehicles can cross at the same time as a locomotive, but street cars and common carriages can pass each other at any place on the bridge. Both masonry and superstructure are being constructed by the Bridge Company, the former having been given over by the original contractors, and the latter being delivered ready for erection at a price per pound, all drawings being furnished by the engineers of the bridge.

This great work has been planned by, and is being carried out under, the supervision of Messrs. Albert Fink, Chief Engineer, and F. W. Vaughan, Principal Assistant Engineer.

Estimated cost $1,600,000, including land and depots.

Safety-Catch for Double Hoists or Inclined Planes.—In the report of the Resident Secretary, at the last meeting of the Institute, was included among other things a description, illustrated by a working model, of the improved safety-catch for double hoists or inclined planes, devised and constructed by Mr. J. V. Merrick. The important feature involved in this apparatus, (as also in that device by the same gentleman, formerly described by us in this Journal, Vol. LVI., page 74,) is that the catch is not operated by a spring or other source of motion which is normally at rest, and likely to become useless without giving any sign of such deterioration, but is thrown into action by what may be called a counter-weight which moves with the rest of the apparatus, and cannot in any way be disarranged without immediate notice and indeed stoppage of the machine, in a secure position. In the present case, each cage or car of the double hoist acts as a counter-weight for the catch of the other.

The catches of the two cars are in fact united by a slack cord passed over pulleys near the hoisting-drum or wheel, and so, if the main rope breaks, the cars beginning to run down, the slack cord is tightened with double their velocity, and the catches instantly engaged. By means of the model, repeated demonstration was made of the efficiency of this arrangement.

Paper Belting.—There was also exhibited at the above meeting a specimen of paper belting, manufactured by Messrs. Crane Bros.,

Westfield, Mass. The new article of belting is made of pure linen stock. Equal durability and driving power with leather belting is guaranteed, except when used for shifted belts; none are made narrower than five inches. It does not stretch, nor change shape, and can be made in one piece, of any desired length and width and thickness, and is uniform in every particular. It hugs the surface of the pulleys closely; generates no electricity while running; is sufficiently flexible to pass over six-inch pulleys without cracking; is not injured by the heat, dust, oil or moisture, incident to ordinary use, and is forty per cent. cheaper than leather.

East River Bridge.—At page 149 of our last number, appears a notice of this work, in which is given a list of consulting engineers: among these is a Mr. Lathrop; this is a typographical or reporter's error in the paper from which this notice was taken; the gentleman whose name should have occupied this place being Mr. Benjamin H. Latrobe, of Baltimore.

Ship Canal between New York and Newark.—A meeting of the company recently organized for the purpose of constructing a ship canal between Newark and New York is to be held in a few days in the city of Newark, to elect a board of directors, $250,000 worth of stock having been subscribed. The capital stock was primarily fixed at $1,000,000, in shares of $50 each; but it was enacted, in 1868, that it might be lawful for the Canal Company to extend their canal from Newark Bay across the marshes to a suitable point in Newark City, and to increase their capital stock to such an amount as should be necessary to carry out the original scheme with the extension, the capital is now fixed at $6,000,000.

The line will run from Dawson street, Newark, extending to Oyster Island, in New York Bay. Thus the line will be almost parallel to that of the Newark and New York Railroad, which is an air line. The total length of the canal will be nine miles. It will be 200 feet wide, as far as the east side of Newark Bay, where it has an increased width of 100 feet, making it at least 300 feet wide at Bergen's Neck. There will be a line of docks on both sides of the canal 200 feet wide, extending the whole length. In Newark there will be piers 300 feet wide, the depth of water being at low tide 16 feet, and 22 feet at high tide, but at the Passaic Channel bank, the depth is only 5½ feet at low tide.

There are difficulties to be overcome in this undertaking, the principal one being that of securing the proper depth of water

in the canal at low tide. The cutting will be the deepest at Bergen Neck, where it is to be 45 feet. The earth from this cutting will be removed to fill up the piers in New York Bay, and these piers, it is said, will be better adapted for commercial purposes than those on the eastern shores. It is intended to run a ferry on the canal between Newark and New York, the distance to be run in 40 minutes. —*Evening Telegraph.*

Elastic Steel Washer, manufactured by William Wharton, Jr., Thirty-second and Walnut Streets, Philadelphia.

This article, just invented and patented, is intended to meet the obvious need of a complete check on the loosening of screw-bolts and similar fastenings subject to severe, unequal strains. It is a *spheroidal steel washer* of varying diameters, from one and a-half to twenty inches, adapted specially to railroad joints, cars, bridges, and locomotives.

The principle of its effectiveness consists in applying sufficient elasticity to meet the elongation of the bolt consequent upon the unequal strain inseparable from the passage of railroad trains at a high speed, this inequality being owing to the *impaired rotundity of the wheel* which is sure to follow either from imperfection in the original casting, or from the sliding of the wheel under the action of the brake. Observant engineers have long been aware of this grave difficulty, it having been ascertained that when a wheel is injured in its periphery, its action on the rail is entirely changed, the flattened part operating immediately as a hammer, and its murderous jar spreading injury and danger in various directions.

The spheroidal shape of this washer ensures the most economical application of power from a given amount of metal under the circumstances of the case, and its diameter and thickness can be exactly adapted to the size of the bolt and the amount of strain to be encountered.

On the New Method of Purifying Oils, invented by M. Michaud, of Honfleur; the report is from the hand of M. A. Chevalier. After having reviewed the different processes in use from the middle of last century, to render fatty oils, such as rape seed and colza oils, more suitable for use in lamps of a more complicated construction, the author of the report states that M. Michaud's process consists of a defecation of the raw oil by the simultaneous introduction therein of jets of air and thin streams of sulphuric acid, whereby those substances contained in the raw oil, which are injurious

to its properties for use in moderator and carcel lamps are coagulated and brought to the surface of the oil as a scum, which can be easily removed; the oil is next washed with water, afterwards heated by steam to 100° C., and, lastly, filtered through cotton and a layer of clean and pulverized marble, at a temperature of 40° C., yielding an excellent material for use in lamps.

New Marking Ink for Linen.—M. Kuhr recommends the following preparation:—One part of hypophosphite of soda, and two parts of gum arabic, are dissolved in sixteen parts of distilled water. The tissue, linen or cotton, to be marked is thoroughly moistened with this liquid and then left to dry. After having become well dried, the following liquid, composed of one part of nitrate of silver, and six parts of gum dissolved in six parts of distilled water, is used as marking ink, with a quill-pen. The mixtures here described are stated to yield an indelible and very deep black-colored ink.

Artificial Ebony.—This material is prepared on the large scale in the following manner:—60 parts of charcoal, obtained from seaweeds, and previously treated with dilute sulphuric acid, and dried, are ground to powder, and mixed with two parts of liquid glue, 5 of gutta-percha, and 2½ of caoutchouc, care having been taken to mix the two latter substances with coal-tar oil, and thus to render them gelatinous; next 10 parts of coal-tar, 5 of pulverized sulphur, 2 of pulverized alum, and 5 of powdered resin are added, and the mixture heated to 300° F. After having been cooled, a substance is obtained, which in every respect is equal to genuine ebony wood, but is far less expensive, and takes a finer polish.

ECLIPSE NOTES.—Photographs of the Chromosphere.—In a letter just received from Dr. B. A. Gould, we find the following interesting paragraphs which, with his permission, we extract:—"An examination of the beautiful photographs made at Burlington and Ottumwa, by the sections of your party in charge of Professors Mayer and Himes, and a comparison of them with my sketches of the corona, have led me to the conviction that the radiance around the moon, in the pictures made during totality, is not the corona at all, but is actually the image of what Lockyer has called the chromosphere.

"This interesting fact is indicated by many different considerations. The directions of maximum radiance do not coincide with those of the great beams of the corona; they remained constant while the

latter were variable; there is a diameter, approximately corresponding to the solar axis, near the extremities of which the radiance upon the photographs is a minimum, whereas the coronal beams in these directions were especially marked during a great part of the total obscuration. The coronal beams stood in no apparent relation to the protuberances, whereas the aureole, seen upon the photographs, is most marked in their immediate vicinity. Indeed, the great protuberance, at 230° to 245°, seems to have formed a southern limit to the radiance on the western side, while a sharp northern limit is seen on all the photographs at about 350°, the intermediate arc being thickly studded with protuberances, which the moon displayed at the close of totality. The exquisite masses of flocculent light on the following limb are upon the two sides of that curious prominence at 93°, which at first resembled an ear of corn, as you have said, but which in the later pictures, after it had been more occulted, and its southern branch thus rendered more conspicuous, was like a pair of antelope horns, to which some observers compared it. Whatever of this aureole is shown upon the photographs, was occulted or displayed by the lunar motion, precisely as the protuberances were. The variations in the form of the corona on the other hand, did not seem to be dependent in any degree upon the moon's motion.

"The singular and elegant structural indications, in the special aggregations of light on the eastern side, may be of high value in guiding to a farther knowledge of the chromosphere. They are manifest in all the photographs by your parties which I have seen, but are especially marked in those of shortest exposure, such as the first one at Ottumwa. In some of the later views they may be detected on the other side of the sun, though less distinct. But the very irregular and jagged outline of the chromosphere, as described by Janssen and Lockyer, is exhibited in perfection.

"This happy result is clearly attributable to the relative shortness of the time of exposure by which the highly photographic rays of the chromosphere have depicted themselves, without obliteration by the mass of coronal light which veiled them from the eye. Let us hope that at the next total eclipse some impressions may be taken with an exposure not exceeding a single second, as you have suggested on p. 210. The inference seems warrantable that in this way, better than in any other, the internal structure of the protu-

berances may be exhibited though other phenomena may fail to record themselves.

"You will observe that some of the brighter, petal-like, flocculi of light have produced apparent indentations in the moon's limb at their base, like those at the bases of the protuberances. These indentations are evidently due to specular reflection from the moon's surface, as I stated to the American Association at Salem, last month. Had any doubt existed in my mind, previously, it would have been removed by an inspection of the photographs.

"I shall send the substance of these remarks to Prof. Coffin, as a sort of postscript to my report, which contains only the results of personal observation at the time."

Abstract of Prof. Young's Report.—The observer was a member of the party under the direction of Prof. J. H. C. Coffin, of the *Nautical Almanac Office*, stationed at Burlington, Iowa.

The instrument employed was a spectroscope with 5 prisms of 45° each, having faces 2¼ by 1¼ inches; the collimator and telescope had apertures of 2¼ inches, with a focal length of 17. These were connected with a "comet seeker" of 4 in. aperture and 30 in. focus, used with an eye-piece, and giving an image of the sun, 2½ inches in diameter, on the slit of the spectroscope. A graduated screen at the slit determined positions of points on the sun's limb, and a wire micrometer measured the positions of spectrum lines. The whole was mounted equatorially with slow motion screws.

Protuberances were noted before the eclipse at + 85° to 100°, large and not very bright; at + 146°, small and bright. The photographs show another at 155°, which escaped notice; also at — 70° to 80° low, but pretty bright; and at — 130°, very large and bright, the principal one. Angles are reckoned on the sun's limb from the North point, + towards the East, — towards the West.

The first contact was observed by watching the gradual shortening and final extinction of the *bright line*, C, in the spectrum of the prominence, which happened to be at the point of contact. The moon's approach was perceived for thirty seconds before its actual appulse; the observation was perfectly easy, and the time determined is certainly to be relied on within half a second, and probably much less. The presence of a prominence at the point of contact is not essential to the success of the method, as there is

everywhere on the sun's limb sufficient depth of chromosphere to answer the purpose.

It is proposed to apply the spectroscope to observations both of the external and internal contacts at the next transit of Venus.

During the totality, the following 9 bright lines were observed in the spectrum, viz: C dazzling in brilliance; 1017·5 (near D, the numbers refer to Kirchhoff's scale,) very bright, but not equal to C; 1250±20, very faint, position only estimated; 1350±20, like the preceding; 1474 (a little below E,) conspicuous, but not more than half as bright as 1017·5; F, next to C in brightness; 2602±2, a little fainter than 1474, position determined by micrometrical reference to the next; 2796, a little below G, the well-known H.γ line in brightness between 1017·5 and 1474; and finally H, or Hδ, somewhat brighter than 1474. B was not seen, it is supposed, on account of a mistake in carrying that portion of the spectrum through the field while there was no prominence on the slit.

*The line 1474 was recognized as belonging to the *spectrum of corona*, in the first place, by its extending clear across the spectrum, while 1017 did not, and then by its remaining visible when the slit was moved away from the protuberance, while the other lines (C and 1017) disappeared. The impression of the observer is that faint lines 1250 and 1350 behaved in the same manner, but his recollection as to this point is not very certain.

These three lines, 1250, 1350 and 1474, coincide far within the probable errors of observation with three lines observed by Prof. Winlock in the spectrum of the Aurora Borealis. The two first are not accurately enough determined, in position, to allow much stress to be put upon any apparent coincidences on their part, but

* A careful examination of the photographs of the prominences on the eastern limb of the sun, upon which the slit of the spectroscope was directed during the first half of totality, somewhat diminishes my confidence in the conclusion of the text, as to the nature of these 3 lines. I think it absolutely certain that they do not belong to the spectrum of the *brilliant portion* of the prominences; but the photograph shows, in addition, an extensive nebulosity surrounding the nuclei, with a pretty definite boundary of its own. This nebulosity is best seen in No. 2 of the totality pictures taken at Burlington. Now, it is *possible* that these lines may belong to this *nebulosity*, and not to the *corona proper;* for I cannot recall, with certainty, whether the 1474 line retained its brilliance at any considerable distance from the prominences. My impression is that it did, and that the text is correct, but do not wish to be too positive. The eclipse of December, 1870, will decide, of course.

the last is perfectly well known, and its exact agreement, throughout with one of the fainter lines of the Aurora, when combined with the general appearance of the Corona and other considerations, give a good deal of probability to the conjecture that *our Aurora Borealis and the Solar Corona are identical phenomena.*

The line 1474 is given by both Kirchhoff and Angström (not by Huggins, who, however, omits many faint lines,) as belonging to the *iron* spectrum, and this suggests the inquiry whether we are to admit the existence of *iron* in the auroral heights of our atmosphere, or are to account for this line in the iron spectrum by some unknown substance of gaseous nature.

The corona showed, also, a faint continuous spectrum without *any trace of dark lines.* The light of this faint spectrum, tested by a tourmaline held in the hand next the eye, was strongly polarized in a plane passing through the sun's centre. As the direction of the spectroscope slit was nearly radial, it is not impossible that Prof. Pickering may be right in explaining this polarization as caused by the successive refractions through the prisms.

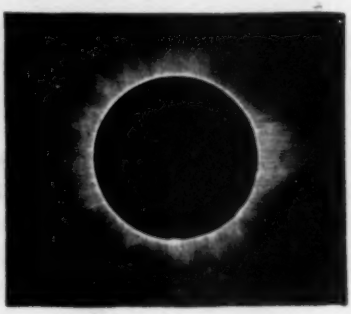
[The two preceding communications from Dr. Gould and Prof. Young, sent to us independently, show a remarkable coincidence in their results which cannot but point to an important fact. To put this into a few words it would seem likely that Prof. Young has observed the spectrum of that diffused chromospheric matter of which Dr. Gould has found the photographic record on the pictures made by the Philadelphia expedition. If reference is had to Plate II. facing p. 265, in Prof. Mayer's Report, in this number, Dr. Gould's description of the location of the glow on the photographs can be readily followed.—ED.]

Prof. Young's Determination of First Contact.—In our notice of this subject in our last issue, page 149, we omitted to notice that Prof. Young finds that the presence of a prominence at the point of first contact, though facilitating the process, is not essential to his method, since the spectrum of the chromosphere is quite enough for the same purpose.

In quoting from his letter on page 213, we also may have given too strong an impressiveness to his suggestion that the corona lines were identical with those of iron. His intention was to notice their apparent approximation merely.

The Corona and its Photographs.—It is a very fortunate thing that the numerous parties by whom photographs were made

of the late eclipse, in hardly any two instances followed the same plan of arrangement or aimed at the same class of results. Thus, while the Philadelphia Expedition, in pursuance of Prof. Coffin's suggestions, made their preparations with the view of obtaining such "accurate and well-defined pictures as might be the basis of astronomical calculations." In this they have unquestionably succeeded beyond all others, as we hear from all sides, now that pictures have been distributed and compared. Their views of lunar mountains, sun-spots, faculæ, chromosphere, and crepuscule being unapproached, and their views of the solar prominences only rivalled by one obtained by Dr. Curtis.



The party under Prof. Pierce, consisting, photographically, of Mr. Whipple, of Boston, (who, with Mr. Black and the late Prof. Bond, of Cambridge, made, in 1850, the first celestial photograph,) addressed themselves exclusively to the recording of that strange phenomenon, the corona. To secure any impression from this object, which, notwithstanding its apparent brightness is remarkably deficient in photographic power, it was necessary to make a very small image, and to give a very long exposure.

The telescope was therefore arranged to produce an image in its principal focus simply, and during the totality an exposure of 40 seconds was given. By this means a picture was obtained of which the accompanying cut is a very careful copy. From the long exposure and motion of the moon, as also, probably, of the light in the corona, there is little sharpness of definition, and the prominences only appear as bright spots. The general shape of the corona is, however, very well given, and the curious appearance of curvature, in some parts, is very manifest. This and other pictures—if others than the one we have seen were made—may throw some light upon this extraordinary object.

Moon Pictures.—There are few objects which are more difficult to portray, with accuracy, than the surface of our satellite. The combination of shadows, with tints produced by difference of material, the absence of strongly marked and conspicuous features to serve as starting-points for measurement, and the extreme minute-

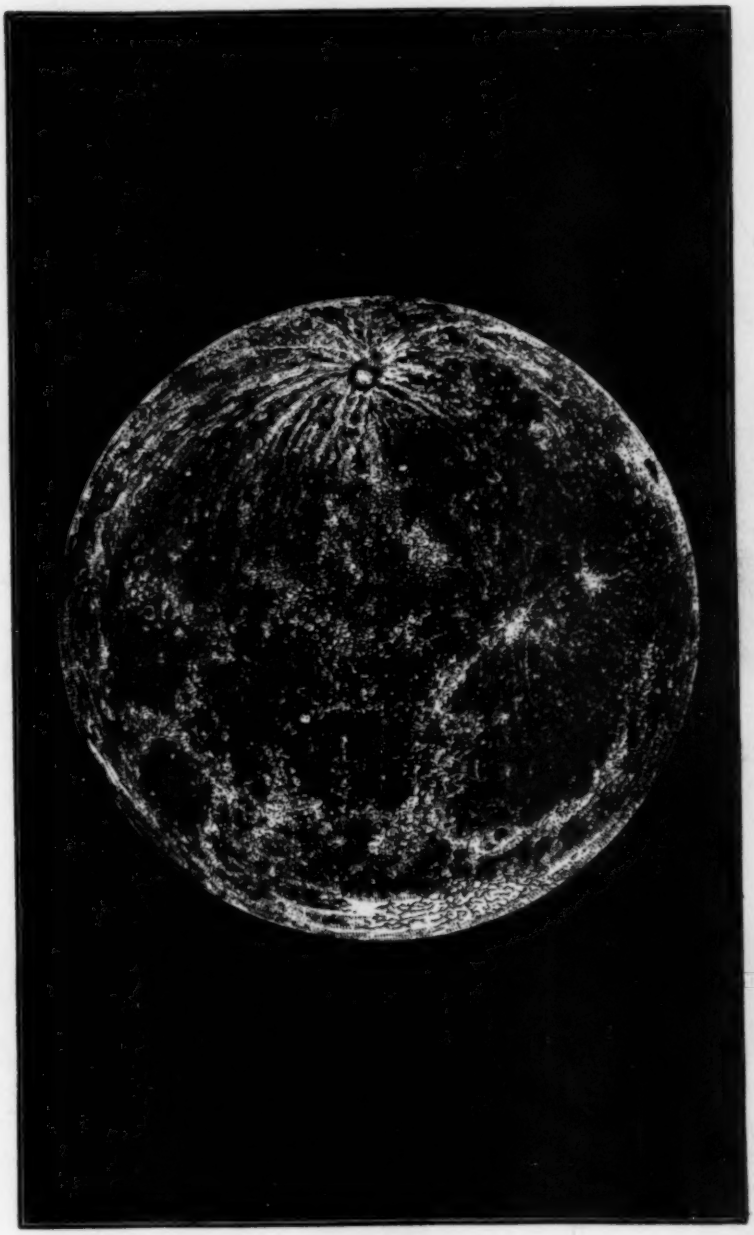
ness and delicacy of markings and tint graduations, have combined to defy the skill of the artist and the engraver. This is especially evident since the successful application of photography has furnished us with such admirable standards for comparison.

In the *Quarterly Journal of Science* for July, 1864, appeared an admirable lithograph of a small region to the S. E. of Tycho, which left all previous attempts far in the rear, and, indeed, for the very limited area concerned, left also little to be desired. This was copied in an excellent wood-cut in the beautifully illustrated work of Guillemin, *La Ciel*, and also as a mezzotint, in a small volume by the same author, entitled *La Lune;* but the large picture of the full moon, given in the same volume, is a mere caricature of the lunar countenance. Two much better pictures have appeared in one of the latest numbers of Louis Figuier's *Merveilles de la Science*. A curious etched daguerreotype by De la Rue was published some years ago in the *Monthly Notices* of the Royal Astronomical Society. This picture is curious as an etched daguerreotype, but of little value as a likeness of the moon, giving only a few prominent points with distinctness. In Vol. LVI., p. 136 of this *Journal*, we published a large lithograph which, by insertion of names and numbers, was made into a map, and this was acknowledged, by the most competent judges, to be the best moon picture produced up to that time.

We now, however, give our readers an engraving that, for artistic beauty and delicate finish, excells even this, though on account of its smaller size, and the nature of the full phase, it is not available as a map, or useful for topographical study, as was the other.

This picture was engraved by Messrs. Van Ingen & Snyder, under our inspection, from one of Mr. Rutherfurd's photographs for Prof. S. H. Peabody, to illustrate his work entitled *The Elements of Astronomy*, now in course of publication. This is, beyond doubt, the best engraving of its kind ever published, and reflects great credit on the artists who have produced it. If the other illustrations in Prof. Peabody's book equal this one, it will be without a rival in this respect, either in this country or in Europe.

Very extensive atlases of the moon are announced as partly published by the British Astronomical Association, but these we have been unable to find, and the descriptions which we have seen indicate that they are mere charts and not pictures.



Engraved by Messrs. Van Ingen & Snyder from a Photograph by Mr. L. M. Rutherfurd.

Editorial Correspondence.

THE USE OF CORNISH ENGINES FOR THE WATER SUPPLY OF CITIES.

MR. EDITOR:—The Cornish Engine, when well regulated and in full operation, presents a most imposing exhibition of the power of steam, and of its control by human ingenuity. Especially is this the case when its work is the elevation of water for the supply of cities and towns, because the entire mechanism is visible at the same time, the pump being situated within the engine house. The observer sees the ponderous plunger tossed upwards, at first with great velocity, gradually coming to rest at the topmost point of its stroke, then descending quietly to the lowest point, always arrested at the same positions, within a short distance of the buffers, apparently without any adequate agency.

Several requisites are, however, combined to produce this result; a failure in either of which will impair the efficiency of the machine, and may, without warning, produce disaster. These conditions are, uniformity in the steam and vacuum pressures, constant frictional resistances in the machine itself, and a steady pump resistance.

The two first named are generally attainable with proper valve-gearing and proper care. The latter condition, in mining engines, is comparatively easy of attainment, because the work is distributed over a series of lifts, and if accident occurs in any one lift by the holding up or breakage of a valve, or otherwise, a fraction of the resistance only is removed. But when this engine is used to drive one pump only, as is customary in water works, such an accident may remove all pump resistance, and serious injury is likely to result.

To avoid this would, I think, be easy (and without great complication,)by the introduction of additional inlet and outlet valves, to be made of or faced with rubber, which valves should be placed respectively below the main inlet and above the main outlet valves of the pump. These supplementary valves should be of larger area of passage than the main valves, and so long as the latter were in action would be subjected to no strain, while they would operate noiselessly, and without creating much additional friction. They

would, therefore, wear very little, and in case of accident to the main valves, would prevent the reflux of the column of water, and would, consequently, maintain the constant pump resistance through the stroke. During the next stroke, in case the difficulty had occurred from chips or dirt, these obstructions to closing would be washed out.

In some of the English water works engines, the same end has been sought by the use of seats carrying several disc or ball-valves, one or more of which may hold up without producing accident. Some engineers, however, prefer metal valves of two, three, or four "beats," and in such cases the expedient alluded to would be applicable, and would operate with greater certainty. In one case in this country, (Buffalo, N. Y.,) the supplementary outlet was employed for another purpose, and with good effect. But it is apparent that accident is more likely to occur to the inlet-valve, and, when it occurs, to break down the engine.

By the expedient referred to, the only serious objection to the use of the Cornish Engine for the purpose named is removed; and as its expense would be comparatively small, the investment would be good, as absolutely preventing that class of accidents which are most common and troublesome.

It is indisputable (on any substantial grounds) that, in point of economy of fuel, the Cornish Engine for pumping water, when properly made, is preëminent. It alone combines the two esentials for such economy, viz: A sufficient mass of moving material to enable steam to be used at high grades of expansion, and a velocity of movement in the water column, dependent solely upon the inertia of that column. The best effect from expanding steam cannot be obtained without the mass of material in which to store the surplus power at first and give it up at subsequent stages of its movement after the steam is shut off. The best result upon the water cannot be obtained, unless this mass of material, when pumping, can accommodate its velocity to that of the water column urged by it.

The various forms of "duplex" or "twin" engines, where the stroke of one piston is limited and reversed by the other piston then moving at its highest speed, are deficient in the first requisite named; and although this defect may be partially overcome by using combined cylinders, it cannot be entirely removed, except at great expense. This class of machines, however, being double-

acting, are deficient, to an important extent, in the second requisite I have named, viz: in accommodating their movement to the normal velocity of the water column.

There are forms of crank engines, in which, by the use of fly-wheels, a proper momentum may be obtained to absorb and give out the surplus steam pressure; but this class of machines are all deficient in their accommodation of speed to that of the water column.

It is evident, from these considerations, that the "Cornish" is, theoretically, the best pumping engine. Practically, it is also the best, if properly made, and with efficient safeguards against accident.

It is easy of management, liable to the least possible amount of wear, and is at least not more expensive in first cost than other forms. And, with the safeguards pointed out in this article, added to others which have been suggested by experience, it would be more free from liability to derangement.

J. VAUGHAN MERRICK.

Philadelphia, Sept. 8th, 1869.

WATER POWER ON DAMS BUILT TO IMPROVE RIVERS FOR CANAL FEEDERS, &c., WHERE A UNIFORM DEPTH OF WATER IS REQUIRED.

MR. EDITOR:—The use of water power on the State dams, in the State of New York, built for the purposes of navigation, was formerly leased to the highest bidder, subject to the control of the Superintendent of Canals. The lessee was allowed to cut into the dam for a flume, from which the water could be used on all the various wheels in use. But it was soon found impossible to control water enough, in a dry time, for the purposes of navigation. The leakage of gates, bulkheads and flumes, and the clandestine use of the water, after the Superintendent had forbidden it, as provided by the lease, was so great that it was impossible to keep a uniform depth of water in the canals. Therefore, the Legislature abolished the leasing of water power on any of the State dams, which deprives the State, as well as the people, of more than half the usefulness of such dams, as water power is nowhere so useful as when situated on navigable waters, which afford the best facilities for transporting the raw materials required by the machinery as well as the produce

from them, adding largely to the tolls on and usefulness of the navigation.

Such is the necessity of the following plan for using the water without cutting into the dam at all, avoiding the possibility of drawing down the water below the top, using only the water as it falls over the dam, and would otherwise go to waste. This plan has no flume, bulkhead or gates. The navigation is first supplied, the waste is then utilized by machinery, which usually amounts to much more than is used for navigation.

Fig. 1 represents the water in use. Fig. 2 represents the water shut off from the wheel and passing off over the apron, with the same freedom as when in use. All of the machinery, both for working the apron or gate, and the mill, is situated under the apron. The upright shaft, which conveys the power to the mill, stands below the abutment of the dam out of the water passage, and connects, by bevel cog-wheels, with the extended water-wheel shaft. There is not the slightest obstruction to the passage of the water, whether in use or not; nor can the surface be drawn down any lower than it would be if no mill was there, thus doing away with every possible objection to the use of a large amount of waste water power, situated where it is most wanted for the benefit of the canals as well as the people.

Fig. 1.

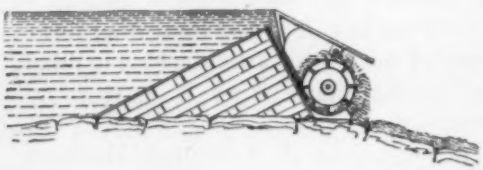
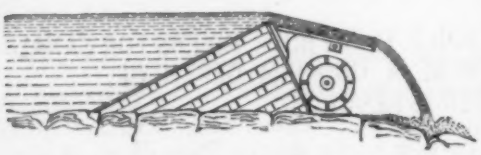


Fig. 2.



This method, in other cases, wherever there is no object in preventing the water, when not in use, from passing off, will be found very economical and efficient in the use of water power for many purposes, as it does away with all expense of flumes, bulkheads, spouts, &c.

D. S. Howard, C. E.

Lyons Falls, N. Y., 7th Sept., 1869.

Civil and Mechanical Engineering.

ON THE CONSTRUCTION OF DAMS AND THE IMPORTANCE OF THEIR PERMANENCE.

By D. S. Howard, C. E.

There are few persons engaged in the building of dams who realize the importance of making them permanent, particularly at or near the head waters of streams. The cost of such dams is but a trifle, compared to the consequences of their failure, in times of unusual floods, the only time when what is called a well built dam will fail. Therefore the better a dam is built, if the work be not planned and executed so as to be permanent under all circumstances, the greater the curse it is to the community below, all the way to the mouth of the stream.

There can be no excuse for the failure of a dam, unless we give up the superiority of the human intellect over inanimate matter. An engineer who does not understand the laws that govern the action of water, or has not conscience enough to create a care for his fellow-creatures, sufficient to build a permanent dam, should not be allowed to erect any structure of the kind on any stream, situated above any other property, liable to damage by the failure of such structure.

Most of the immense damage done by the recent freshets throughout the Northern States, has been due to the failure of dams at or near the heads of streams. The one at the outlet of North Lake, near the head waters of Black River, built by the State of New York for a reservoir, to supply the Black River Canal and Erie Canal Feeder, was one of this description.

The dam was 30 feet high, built across the outlet of a small lake of about 450 acres surface, and was constructed wholly of earth, except a longitudinal course of sheet piling perpendicularly through the centre, with a course of concrete on the upper side of the sheet piling, and a spilling way of wood, in the shape of a shoot, forty feet wide and seven and a half feet deep, on the lower side of the dam; four feet of the seven and a half had been permanently planked up, since the completion of the dam, which is said by Mr. Whittlesey, the builder, to be the cause of the failure.

The next dam below was built by the State across the Black River, to turn the water into the canal feeder. The spilling way to this dam was about twelve feet high, and one hundred feet long, with an upper slope of two to one, on a rock foundation, between two short, square stone abutments, with earth-works each way to high land.

The first of these dams was destroyed altogether by the recent freshet. The second was left entirely bare of earth-work on one side, leaving nothing but the stone and wood-work, which stood perfectly erect in the middle of the torrent, which shows conclusively, that if the whole had been as well planned, there would have been no failure.

Notwithstanding the immense flood thus created, there were numerous dams on the same stream below, that sustained little or no damage. But not so with other structures necessarily situated near them, such as grist-mills, saw-mills, tanneries and other works dependent on them, for the power created for their purposes, together with bridges and dwellings, barns and outhouses, heretofore considered out of reach of any possible flood. It is estimated that more than a million of dollars worth of such property has been swept from their foundations on this river, besides the loss of lives and the distraction of business, which cannot well be estimated in money value.

The Legislature of the State of New York being in session, promptly ordered an estimate of all the damages done by the recent freshet on the Black River, with a view of remunerating the individual pecuniary losses, so far as they can be estimated, by which it becomes a direct national calamity, so far as the remuneration goes, but no person will say, that all the indirect damages will ever be paid by the State, therefore whatever the State does pay, would have been better invested, if it had all been paid to an engineer capable and careful enough to have planned and executed the above works, in accordance with the simple laws which govern the action of water, thereby saving a large amount to individuals, (as well as some human life,) which is no less a loss to the state, for whatever is a loss to an individual in the State, and a gain to no other similar individual, is as much a State loss, as it would have been if the individual had been remunerated by the State.

One of the most apparent causes of the failure of earth-works at the ends of dams, is the short angular form, usually adopted, of the

the lower side of the abutments, which causes a strong eddy below, calculated to undermine the bank adjoining, which is soon so much weakened as to be carried away by the pressure of water above. This observation was observed at the height of the recent freshet, to be going on at the north end of the State dam at Lyons Falls, and, although the abutment was built into the natural bank, it was so far affected by the eddy, caused by the form of the abutment, that the bank began to cave, and cracks high up on the bank indicated that if the freshet had continued at its heighth a few days longer, the whole river would have passed around the north abutment of the dam; adding still another swell, to the disastrous effects of ignorance and carelessness, already created.

Another frequent cause of failure in earth-works of dams, dykes and canal banks is an improper disposition of the material of which they are constructed. If the finer material be placed in the lower side of the embankment, it will prevent the leakage from passing off, and cause the whole embankment to become saturated, rendering it very liable to float away. Whereas if the fine material be placed in the upper side of the embankment, the coarser, with its greater weight, stands with greater firmness as a support to that which stops the water, and by more readily letting off the water that may permeate the finer material, leaves more weight in the embankment to resist the pressure of water. Too much care cannot be taken in selecting the finest impervious material, for the upper side surface of an embankment for stopping water. This done, the remainder of the material should be gradually coarser towards the lower side, which, if convenient, should be a course of stone. A dyke or embankment, properly built on this principle, with six feet top surface, with slopes of one and a half to one, may be extended to any heighth, and sustain a pressure of water within one foot of the upper surface, with perfect safety.

But if the material be so disposed as to permit the water to saturate the embankment without passing off, the weight of the embankment will be diminished, to the extent of the weight of water contained in it.

The spilling way to dams, if on a rock foundation, may be constructed perpendicular on the lower side, with a water-tight upper slope of two to one, and be perfectly safe without bolting to the rock, whether it be built of stone or wood, if the lower side be open to offer a free passage for the water that may pass through the

upper slope. But if on a foundation of loose stone or gravel, which is sometimes unavoidable, there must also be a water-tight slope on the lower side of about one to one, down to a horizontal water-tight apron, about eight feet wide, sunk below the bed of the stream. If the apron be above the bed of the stream, it will be liable to be undermined by a verticle eddy, formed by the horizontal force of the water leaving the apron, acting on the dead water immediately below the surface, on the lower side of the apron.

On some foundations where the water is to be raised very high, it will be necessary to dig a puddle ditch at the foot of the upper slope, six feet wide, and as deep as the nature of the material requires, in which sheet piling should be driven as deep as possible, and the upper ends well fastened to the bed timbers of the upper slope. Then fill the ditch above the sheet piling with clay and gravel about half and half, well puddled in, to about four feet in heighth above the foot of the slope, and extending up on the slope one-third of the way to the top, where a timber one foot square, should be bolted, from one abutment to the other, to prevent the current, in great freshets, from carrying the gravel over the dam.

It is impossible to reduce the building of dams to perfect science, but the laws which govern the action of a perfect fluid, are known to be in accordance with exact science, and must be understood by the constructor of dams to ensure success, as water is so near a perfect fluid, their strict observance will in all cases be required for its control.

The hydraulic engineer must not only know the weight of water, the static pressure and dynamic force, but the effects of various forms of resistance with which it may meet. He must also understand the laws relating to the conditions of the various materials upon which dams are to be built, the simplest of which is solid rock, hard pan, &c. Most other materials partake, in some degree, of the nature of fluids, according to the degree of friction between the particles, or the power required to put them in motion.

The pressure of water being equal in every direction, according to the weight and perpendicular heighth, loose materials in foundations of very high dams, if allowed to become saturated, will assume the character of a fluid sufficiently to be pressed out from under the superstructure, by the weight of water above, causing an upward pressure below. Hence the necessity of sheet piling and concrete or puddling above, to cut off all communication as

much as possible, between the water in the pond above and the material beneath the dam, or to such an extent as to prevent the water from entering the foundation, faster than it can pass off, without moving the material with it.

The great importance of permanence in dams is only realized by those interested in water power, whose works must necessarily be as near the water as the highest natural freshets will permit. It is possible to convey water power to situations where it may be used in perfect safety from any flood, by various mechanical contrivances; but not without a sacrifice of power, and expense of construction and repairs, which would far exceed the extra expense of building permanent dams, on any important stream.

While we have laws against nuisances, and many comparatively useless laws, it would seem expedient to have, in addition to the laws against flowing land above dams, to have some against flooding lands and other property below. In answer to this it may be said that common law is sufficient to collect damages in case of carelessness of all kinds; but a man may be able to build a worthless dam, and jeopardize a large amount of property below without being able to pay any part of the damage that may be done by the destruction of his own. Therefore it would seem to be a salutary precaution, if he could have been obliged to give bail for the damages that might be done by a failure of his dam. Truly the world is governed too much, but evidently not too wisely.

Lyons Falls, August, 1869.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 163.)

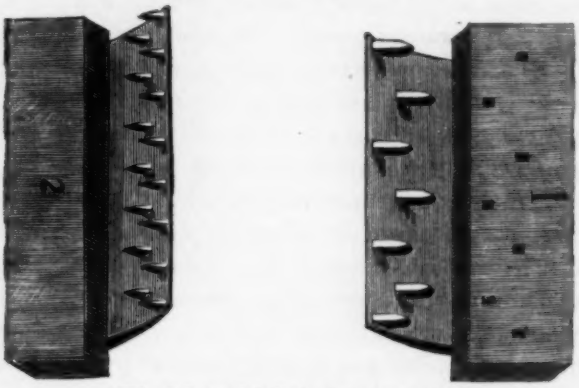
Wilson's Patent Belt Hooks.

We are indebted to Crane Bros., Westfield, Mass., for description and illustration of the above, which we present herewith.

No. 1.—The teeth go through the belt and clinch. To be used only on belts running at very high speed over small pullies, and in making up belts, instead of lapping, glueing and pegging.

No. 2—Is the only belt hook in the market that can be used repeatedly and successfully more than once. A hammer is all that is required to secure them to belts. Lay the hook down on some-

thing solid, with the teeth up, and *drive the belt down tight* to the plate. None of the belt is cut away by punching holes. The strain comes in *fifteen* places instead of *three*, as with lacings. Belts can be mended in one-quarter the time required for any other hook or lacing. They will last longer than a dozen lacings. They are the *only good* fastening for rubber or paper belts.



Wilson's Patent Belt Hooks, December 15, 1869.

These hooks have been thoroughly tried for three years, in all places, in machine shops, cotton, woolen and paper mills, and all who use them admit that they are the *best* and *cheapest* fastening in use, taking into account the *durability* of the hooks, *wear* and *tear*, and *time* in *mending* belts.

The Messrs. Hoyt Bros., of New York, present a patent belt fastening in the form of a double shanked rivet with a link or elongated washer having a perforation at each end for receiving the end of each rivet.

These rivets are used for making butt as well as lap joints in belts; in either case the belt is punched as for lacing, with holes equidistant from the joint. The perforation, of course, being of such size and distance asunder as to just allow the double rivet to pass tightly in when the whole is secured by laying on the link washer and hammering the ends of the rivets into the countersunk holes of the latter, care being taken to embed both head and washer in the substance of the belt, flush with the surfaces, in order that they may not wear by contact with pulleys.

They also have the exclusive right to use a patent "Rivet and Burr." This improvement consists of a conically formed head to the rivet, which gives greater strength of attachment thereto. The

Burr has a form similar to that of the head, and has in addition a central hole countersunk on top for receiving the spread of metal of rivet end when hammered into it. This is the best form of rivet that can be made, as it gives the greatest strength and durability to all the parts, and is easily sunk into the substance of the belt to a level with its surface.

They recommend for round belts a grooved pulley in which the section of groove shall be neither triangular nor semicircular, but rather that of a spherical triangle or gothic arch.

This form undoubtedly gives greater belt contact than any other with a given amount of tension on belt.

They also urge the importance of covering pulleys with leather, "fifty per cent. more work can be done by machines without belts slipping if so covered." "The covering of pulleys with leather, in many establishments where there is a deficiency of power, would produce such an improvement as to astonish those not acquainted with its value."

"Large pulleys and drums may be covered by narrow strips of leather, wound around spirally, but narrow pulleys should be covered by leather of same width as pulley face."

"One pulley covering is cut into strips of required width cemented and made of even thickness, by a machine, then wound in coils like belting."

Errata.—On page 107, 8th line, 888·88 should be 88·888.

On pages 108 and 109 the paragraph commencing :—"Where pulleys," &c., and "The intermediate pulley," &c., should be credited to *Engineering* for Jan. 22d, 1869.

On page 109 the paragraph commencing "A leather belt," &c., should be credited to Jas. B Francis, C. E., in *Frank. Inst. Jour.* for May 1866, page 343.

(To be continued.)

THE HYDRAULIC SWING BRIDGE OVER THE OUSE.

By Sir William Armstrong.

The formation of the Hull and Doncaster section of the North-eastern Railway necessitated the crossing of the River Ouse by an opening bridge, so as to admit the passage of the important traffic carried on in large sailing-vessels. It was also necessary that there should be not more than one pier in the navigable channel, with a clear opening of not less than 100 feet on each side. The requisites of the railway and river traffic necessitated a construction that ad-

mitted of being opened and closed very rapidly. It was also necessary that the power applied should be capable of controlling with great accuracy the momentum of so ponderous a mass, and hydraulic power, being so eminently qualified for this purpose, was therefore selected as the agent. The instances in which hydraulic power had been previously applied to the opening and closing of movable bridges are very numerous, amounting to upwards of fifty examples. Most of these bridges have been erected for the passage of railway traffic, both on main lines and branches, and they may be divided into three classes. 1st. Swing bridges on which the bridge is lifted from its solid bearings by a central press previously to being turned by hydraulic pressure. 2d. Swing bridges on which the bridge rests upon a circle of two rollers, and is turned by water pressure without being lifted. 3d. Draw bridges on which the movable platform is drawn back and pushed forward in the line of the roadway by means of hydraulic machinery. In addition to the hydraulic bridges comprised in these three classes, there is one example of a bridge on the bascule plan being worked by hydraulic power. This is at Liverpool, over one of the dock entrances. The first hydraulic swing bridge was erected in 1852, over the River Severn, on the Gloucester and Dean Forest Railway, and the first hydraulic drawbridge was erected in 1853, over the River Tovey, on the South Wales Railway, near Carmarthen. All the swing bridges which turn on a centre pier, and span an opening on each side, have been made to turn on live rollers without being lifted; because, in bridges of that construction, neither extremity can have any steadying support in the act of turning, but in some instances a central press has been applied to relieve the rollers of part of the weight. Where single-leaf swing bridges are lifted by a central press, the deflection is taken off by letting down the bridge upon its solid bearings when closed; but in the case of drawbridges and swing bridges not lifted by a central press, hydraulic machinery is applied to lift the overhanging end or ends so as to take off the deflection after closing. The openings crossed by these various forms of bridges have varied from 30 to 100 feet span. The heaviest bridge to which the central lifting arrangement has been applied is one over the Regent's Canal, near the London Docks, in which instance the weight lifted and turned amounts to 450 tons. In bridges with the central press, the head of the lifting ram fits into an inverted cup upon the bridge to allow of oscillating movement,

and the bridge in swinging turns upon the water by carrying the ram round with it. The pressure of water employed in the central hydraulic press is about 800 pounds per square inch, and in the largest of these bridges the diameter of the ram turning upon the water is 51 inches. In most cases the bridges are in connection with a system of hydraulic pressure applied to cranes and other machines in the vicinity, the pressure being supplied in the usual manner by steam engines pumping into accumulators. But in some few instances where there is not such a supply of power at hand, the pressure is supplied by hand pumps charging the accumulator, and thus storing up the power ready for application whenever required. At the Ouse Bridge there was no supply of hydraulic power at hand, and in that instance the total power required was too large to be supplied by hand labor. It was further necessary, on account of the position of the swing bridge, either to convey the power to the centre pier by a pipe under the bed of the river, or to produce it upon the pier by placing a steam engine within the pier itself, and the latter plan was adopted. The total length of the bridge fixed and movable, is 830 feet. The fixed portions consist of five spans of 116 feet, from centre to centre of piers. The bridge being for a double line of railway, each span is composed of three wrought iron girders of the bow-string form, the centre girder having a larger section to adapt it for its greater load. These girders have single webs, and are 9 feet deep in the centre. The total width of the bridge from outside to outside, is 31 feet. Each of the piers for the fixed spans consist of three cast iron cylinders, of 7 feet diameter, and about 90 feet in length. The depth from the under side of the bridge to the bed of the channel, in the deepest part, is about 61 feet. The headway beneath the bridge is 14 feet 6 inches from high water datum, and 30 feet 6 inches from low water. The swinging portion of the bridge consists of three main wrought iron girders, 250 feet length, and 16 feet 6 inches deep at the centre, diminishing to 4 feet deep at the ends. The centre girder is of larger sectional area than the side girders, and, instead of being a single web, is a box girder 2 feet six inches in width, with web-plates 7-16th to 5-16th inches in thickness, and the top and bottom boom contains about 132 square inches of section. The roadway is carried upon transverse wrought iron girders resting upon the bottom flanges of the main girders. In the centre of the bridge the main girders are stayed by three transverse wrought

iron frames securely fixing them together; and over the top of these frames a floor is laid, from which the bridge-man controls the movements of the bridge. An annular box girder, 32 feet mean diameter, is situated below the centre of the bridge, and forms the cap of the centre pier; this girder is 3 feet 2 inches in depth, 3 feet in width, and rests upon the top of six cast iron columns—each 7 feet diameter—which are arranged in a circle, and form the centre pier of the bridge. Each of these columns has a total length of 90 feet, being sunk about 29 feet deep in the bed of the river. A centre column, 7 feet diameter, is securely braced to the other columns by a set of cast iron stays which support the floor of the engine room. This centre column contains the accumulator, and forms the centre pivot for the rotation of the bidge. The weight of the swing bridge is 670 tons. There is no central lifting press, and the entire weight rests upon a circle of conical live rollers. These are 26 in number—3 feet diameter and 14 inch width of tread—and are made of cast iron, hooped with steel, and they run between two circular roller paths 32 feet in diameter. These roller paths are 15 inches, and are made of cast iron, faced with steel; the axles of the rollers are horizontal, and the two roller paths are turned to the same bevel. The turning motion is communicated to the bridge by means of a circular cast iron rack 12½ inches wide on the face, and 6½ inches pitch. It is shrouded to the pitch line, and is bolted to the outer circumference of the upper roller path. It gears with a vertical bevel wheel, which is carried by a steel centre pin, supported on the lower roller path. This is driven by a pinion connected by intermediate gearing with the hydraulic engine. There are two of these engines, duplicates of one another, either of which is sufficient for turning the bridge. The force required to turn the bridge is equal to about ten tons applied at the radius of the roller path. Each hydraulic engine is a three cylinder oscillating engine with simple rams 4¼ inches in diameter and 18 inch stroke. These engines work at 40 revolutions per minute, with a pressure of water of 700 pounds per inch, and are estimated at 40 horse power each. The steam engines for supplying the water pressure are also in duplicate, and are double cylinder engines, driving three throw pumps 2·8 in diameter and 5 inch stroke which deliver into the accumulator. The diameter of the steam cylinders is 8 inches, and the stroke of the piston is 10 inches, each engine being 12 horse power. The accumulator consists of 16½ inch ram,

with a 17 feet stroke, and is loaded with a weight of 67 tons, the weight being composed of cast iron segments suspended from a crosshead and working down in the cylindrical casing formed by the centre cylinder. For the purpose of obtaining a perfectly solid roadway when the bridge is in position for the passage of trains, and also for securing the perfect continuity of the line of rails, the following apparatus is applied. Each extremity of the bridge is lifted by a horizontal hydraulic press, acting upon levers forming a toggle joint, the piers having two rams acting in opposite directions upon two toggle joint levers, which act one upon each side of the end of the bridge, and they are connected by a horizontal bar, which is confined by a stud sliding in a vertical guide, so as to ensure parallel action of the two toggle joint levers, and producing exactly parallel lifting of the two sides of the bridge. Three resting blocks, one under each girder, are pushed home when the end of the bridge is lifted, by means of two separate hydraulic cylinders, and the bridge is then let down upon the resting blocks by the withdrawal of the toggle joint levers, and the bridge ends are then perfectly safe for trains to pass over. The hydraulic cyinders for this fixing gear at the two ends of the bridge are worked by the bridgeman from the centre platform by means of two levers, and for the purpose of enabling him to regulate the stopping of the motion of the bridge at the right place an indicator is provided, consisting of a dial upon a pedestal. This dial has two pointers, which are actuated by the motion of the bridge. One of these pointers makes two revolutions, and the other 42 revolutions for one complete rotation of the bridge. These pointers are similar to the hour and minute hands of a watch, the slower pointer being analagous to the hour hand, and the quicker one to the minute hand. The bridge has no stop to its movement, and would swing clear past its right position if the turning power were continued, but the bridge-man being guided by the indicator, knows when to stop and reverse the hydraulic engines, for the purpose of stopping the bridge at its right place. When this is done, a strong bolt, 3 inches thick, in each end of the bridge, pressed outwards by a spiral spring, is shot into a corresponding notch in the fixed girder work, so as to lock the bridge; and when the bridge is required to be opened, these bolts are withdrawn by a wire cord leading to the platform on which the bridgeman is stationed. As the accumulator is stationary, and the fixing gear at the ends of the bridge travels with the bridge, the commu-

nication of water power is made by a copper pipe passing up in the axis of the bridge, through the middle of the centre girder, having a swivel joint at the lower end. Also, as the hand gear for the bridge-man rotates with the bridge, while the hydraulic turning engines are stationary, the communication for working the valves is made by a copper rod passing down through the centre of the above pressure pipe in the axis of the bridge. This rod is connected by levers direct with the regulating valves of the hydraulic engines, and the engines are reversed in either direction by the action of a small hydraulic cylinder, which is governed by the movement of a three-port valve, actuated by this rod from the bridge-man's platform. The cylinders for working the fixing gear at the ends of the bridge are worked by valves placed upon the centre platform, in reach of the bridge-man, the pipes between the valves and the cylinders passing along the side of the roadway of the bridge. The time required for opening or closing the bridge, including the locking of the links, is only half a minute, the average speed of motion at the extremities of the bridge being 6½ feet per second. For the purpose of ensuring safety in the working of the railway line over the bridge, a system of self-acting signals is arranged, that is actuated by the fixing gear at the two ends of the bridge, and a signal of "all right" is shown by a single semaphore and lamp on the fixed part at each end; but this cannot be shown until each one of the resting blocks and bolts is secured in its proper place.

The paper was illustrated by a series of diagrams, to which, as the paper was being read, Mr. Westmacott directed attention where necessary, to render the details of the bridge more lucid and intelligible.

A discussion ensued upon the subject of the paper, and afterwards Mr. I. L. Bell proposed a cordial vote of thanks to the President for his able and valuable paper. Mr. Bell stated that nothing could exceed the perfect manner in which the work had been executed, and so gratified were the directors of the North-Eastern Company, that they had placed upon the transactions of the Board a minute, recognizing their entire satisfaction at the manner in which the work had been done.

The motion was carried with acclamation, and the President briefly acknowledged the vote.

The President announced that the directors of the North-Eastern Company had courteously offered to place a special train at the service of the members of the Institute, in order that on their return south on Saturday they might visit the bridge.—*Engineering.*

Mechanics, Physics, and Chemistry.

ON VARIOUS PROCESSES FOR PRESERVING TIMBER.

By Dr. Adolph Ott.

(Continued from page 193.)

The light oil was found to be of no avail, for the wood treated with it decayed within the same period of time as wood that was not treated at all. The delay in time, in the decomposition produced by aniline oil, amounted only to 6·66 per cent., which, indeed, is a very insignificant period.

It is well known that carbolic acid affords an excellent means for preserving animal matter from putrefaction. This fact has led to the conclusion that the heavy tar oils would be as excellent for preserving wood, they being the chemists' source for carbolic acid. Rottier found this hypothesis unconfirmed. Decomposition set in after the usual period of time, whether the acid was employed in solution in benzine, or otherwise. Tar oils which contained not a trace of carbolic acid, proved to be just as effectual, or strictly speaking, "ineffectual," as oil to which a considerable portion of the acid had been added. Naphthalin has proved to be very powerful in protecting collections of natural objects against the ravages of insects. It might therefore appear that it was the proper agent for preserving wood. This is not the case; it being too volatile to be adapted for the purpose in question, where time and external agencies play such an important part. Quite favorable results were obtained with the greenish fluorescent oil, that comes over at the last stage of the distillation. Direct trials with pyren and paranapthalin, however, did not yield successful results, wherefrom it must be concluded that it is the green fluorescent oil to which the preserving action of coal tar must be attributed. The only question which presents itself is, does the tar contain sufficient quantities of this fluorescent oil, so as to justify the employment of coal tar for preservative purposes?" From an extensive experience, and the collective testimony of others, I am inclined to answer this question rather in the negative than in the affirmative sense.

Importance of the protection of Forests. Lamentable results of their devastation.

In speaking of the supply of ship timber in this country, Mr. William W. Bates, of Chicago, Illinois, says:—*

* Report of the Commissioner of Agriculture, for the year 1866; page 490.

"From navy yards to cooper shops, from railroads to street-alleys, and from bridge-building to shingle making, there is no quarter given to the oak, and no peace to the pine. When we reflect that more than *sixty trades* and nearly *half a million artizans* flourish and prosper by consuming wood in manufactures in the United States, and that by far the greater proportion of woods used are the very kinds preferred in ship-building, it will become manifest that there is real cause for serious consideration of the subject of future supplies. Ship timber now costs nearly or quite double what it did ten or twenty years ago; and what is more, certain influences are at work narrowing the circle of woods eligible for construction, and thus increasing the difficulty of building a vessel for a moderate price. It will yet become a question of some importance among ship owners whether there are not other timber growths than oak and pine to be found in the forests of the United States, from which good and durable vessels may be built for reasonable prices. When a full and complete course of mechanical and philosophical experiments shall have made the commercial community acquainted with the timber properties of all the trees of our great country, of which the wisest must confess the want of information up to this time, many will wonder at the present general assumption that only a few kinds of trees would furnish timber fit for ship building."

And let us add with Frederick Starr:—

"When we remember that it is through their (the ships) instrumentality that those articles are brought which yield such a national income to the Government, surely wood stands forth, demanding again the acknowledgment of its value and power, which thoughtless men have never given to it."*

Let us look, besides, at the buildings of brick and stone, at the thousands of farm-dwellings, the manufacturing establishments, the railroads, everywhere we meet timber under a new aspect. Wood, according to the last mentioned author, pays more than one-half of the entire internal revenue of the United States. Let us glance on the other hand, at the desolation with which many once beautiful and fertile regions of Europe have been overwhelmed in the time of one single generation by the destruction of its forests. In considering the yearly devastation of our American forests, it becomes at once evident that the question of the saving of wood constitutes

* American Forests, their destruction and preservation. Report of the Commissioner of Agriculture, for the year 1865; page 233.

one of the most important subjects of political economy. Indeed, the interest of wood, according to Starr, will place the interests of cotton, wool, coal, iron, meat, and even grain, beneath its feet.

Fortunately, like the "cloud no bigger than a man's hand, just rising from the sea," a lively interest begins to awake on this subject. In the legislative halls, as well as in the rooms of scientific societies, in agricultural and technical periodicals, the subject of the preservation of wood is being discussed with an earnestness and eager search for truth, which must command our highest interest and participation.

Probable causes of the decay of Wood. On instances when timber does not rot.

In the foregoing, the author has endeavored to throw some light on various processes which have been brought to the notice of the public. Not having found any one of them perfect, he now proposes to discuss the main points to be kept in sight in any attempt for the solution of this most important problem.

The decay of timber, or the peculiar transformation which makes it unfit for practical purposes, seems to be in most instances produced by the attack of fungi and lichens.

Whether it be necessary that the sap upon which they thrive, should be in a state of fermentation, or whether it is seized when yet in an unchanged state, is not yet decided, but worthy of investigation. The access of air seems to be necessary in so far as the fungi themselves need oxygen; it is, however, improbable that the albumen is the only substance of the juice on which they are capable of vegetating, for the fact that the presence of albuminous substances is not conditional in other and well studied modes of fermentation. Timber is naturally more subject to rot when perforated by the larvæ of insects, or if deprived of its bark, or otherwise damaged.*

Trees which are hewn when the motion of the latex is greatest, are most susceptible to decay. Trees with an abundance of sap, as maple, red and white beech, are little durable. The sap wood

* The *mouldering* of wood is distinct from decay, it being merely a chemical process caused by the action of water with small access of air. This process requires centuries, and its consideration would therefore be of no practical importance in a discussion on the decay of wood. It is most probable that the lignites and mineral coals are the products of the mouldering of wood. The process alternately causes evolution of carbonic oxide, carbonic acid, and marsh gas. Instances of the preservative action of water upon (originally sound) wood, are the old Spanish dwellings of the Canaries, built in 1402, utensils from lacustrine inhabitations, and roots submerged in marshes. Hartig describes a submerged cypress stem with over 3000 year rings, of which the innermost are said to be perfectly compact and little altered.

always rots first. Wood, on the other hand, when well seasoned, and kept in dry situations, generally withstands decay for a considerable length of time, but if exposed to dampness, it will soon begin to rot.* Timber that has already undergone decomposition, may be saved from further destruction by being subjected to steaming in close chambers. This is explained by the fact, that the microscopic plants mentioned, or their spores, are killed by an elevated temperature.

"Perhaps the most simple and practical method for preserving timber," says William Bates,† "is by subjecting it properly to the action of water and air. By the action of *water* it may be deprived of all those vegetable matters contained in it which are soluble in water, and which by heat and moisture, are caused to ferment and rot. * * * * * By the action of *air*, the water and moisture contained in the timber may be evaporated, and the fibres of the wood be brought closer together by the loss and shrinkage of the vegetable matters deposited between them."

With respect to the first step, it may be mentioned that it is an ancient practice in England to steep the oak planks for threshing floors, and those intended for the wainscoting of houses, in running water. Timber, treated in this way, is said to endure for an immemorable time; but this process, though effectual, is by far too slow to be practicable. Again, when such wood is placed under conditions favorable to decay, it will soon begin to rot, either because only part of the sap has been withdrawn, or because foreign substances have gained entrance. Moreover, such wood is always liable to warping and shrinkage; it will check and crack, and when connected with other materials, as in buildings, it will check and crack them also.

* The hygroscopic nature of the wood prevents the total expulsion of water by air drying, for Rumford found that air dried woods heated to 277° Fah., lost weight (per cent.) without being altered, as follows:

Oak wood lost	16·64
Elm	18·20
Beech	18·56
Maple	18·63
Fir	17·53
Birch	19·38
Lime	18·79
Poplar	19·55

(*Encyclopedia of Chemistry*, by James C. Booth, assisted by Campbell Morfit. Second edition. Philadelphia, 1862. Article, "wood.")

† Vide his article on Ship Timber in the United States, in the Report of the Commissioner of Agriculture for 1866: page 494.

(To be continued.)

SOLAR ECLIPSE OF AUGUST 7, 1869.

(Continued from page 216.)

REPORT OF ALFRED M. MAYER, PH.D.

(Chief of the Burlington Section of the Philadelphia Photographic Expedition.)

To Prof. Henry Morton, Ph.D.

DEAR SIR:—I herewith present to you my report, as chief of the Burlington section of the Photographic Expedition, organized by you under the authority of Prof. J. H. C. Coffin, U. S. N., Superintendent of the Nautical Almanac.

This report is given under the following heads:

1. Diary of work at Burlington up to the time of the Eclipse.
2. The Station, with a Map of the same.
3. The Equatorial and its Adjustments in Altitude and Azimuth.
4. The Camera and Chronograph.
   - (*a.*) The adjustment of the Reticule of the Camera.
   - (*b.*) The experimental determination of the time of exposure during partial phase.
5. The Work during the Eclipse.
6. Description of the Photographs taken.
7. Results.
   - (*a.*) Time of First Contact.
   - (*b.*) Position-angles of first and fourth contacts.
   - (*c.*) Angles of position and heights of the protuberances.
   - (*d.*) Measurements on the solar spot in S. W. quadrant.
8. Observations on the application of Photography to the determination of the times of contacts during the transits of Venus in 1874 and 1882.

1. *Diary of Work at Burlington up to the time of the Eclipse.*

Our party, consisting of Messrs. O. H. Willard, H. C. Phillips, J. Mahoney, O. H. Kendall, Miles Rock (who accompanied the expedition as my special assistant), and myself, arrived at Burlington, Iowa, about noon on Wednesday, Aug. 4.

We were here received by Prof. Coffin, who had previously selected our station of observation, and on it had erected a building to contain the equatorial, with adjoining rooms suitable for photographic purposes. The afternoon was occupied in the transportation of our boxes to the observatory and in unpacking and mounting the telescope; while Mr. Willard made some additions to the

photographic rooms and modifications in their arrangement. We had progressed so well with our work that by sun-down we had put together the base and frame of the telescope, had mounted bed-plate, polar and declination axes and circles and the cradle which holds the telescope tube.

On Thursday, Aug. 5, the tube was placed in the cradle and all the parts of the telescope were put together and oiled. The verniers were now adjusted opposite each other, and the instrument was brought into altitude adjustment to within 1′ by the process described below.

Mr. Austin, of the Nautical Almanac Office, at the request of Prof. Coffin, had previously run a meridian line on the cross timbers which supported the base of the telescope and, as near as could be determined, I brought the polar axis and this line into one plane. This forethought of Prof. Coffin greatly expedited the bringing of the equatorial into position, and I afterwards found from star observations that the azimuth adjustment required to be touched but slightly.

We rose on Friday morning, Aug. 6th, to see a driving rain, with an east wind, and the same dull murky atmosphere which we had had all the day before. Yet we went on attending to the details of arrangements for the coming day as though we *could* not be disappointed after weeks spent in previous preparation for the work of to-morrow, and after having come over a thousand miles to carry back with us the long thought of eclipse, fixed on our plates in *appearance*, *time* and *position*.

As we retired there appeared a breaking away in the clouds and Dr. Gould told the clerk in the office to "wake us up if the stars came out." We had barely lost ourselves in cloudy slumber when the clerk knocked at the door with "Get up! *plenty* of stars!" We were soon dressed and came out to be charmed by the sight of a cloudless sky, and Prof. Coffin, Dr. Gould and I were up all night, putting our own special instruments in adjustment, and, at the same time, helping each other as we could. When all was finished the sun was rising over the trees on the opposite bank of the Mississippi and the air was as pure and as serene as one could wish.

On Saturday morning the chronograph was mounted and wires were led to the camera, to Prof. C. A. Young's spectroscope and to the station of Dr. Gould outside the building. The two threads of the reticule of the camera were placed one parallel and the other at right angles to the celestial equator. Mr. Willard now began ex-

periments to ascertain the chemical focus and his success in this delicate adjustment will speak for itself to all who examine the beautiful details of the photographs.

It is here important to remark that the chemical focus was obtained after the tube had been following the sun for an hour or more, and after the focus was fixed, the clock-work was kept going so that *no change in focus* should supervene from a change in temperature in the lenses and tube; which change of focus certainly would have occurred if we had closed the roof of the observatory and had uncovered only a short time before the eclipse.

By 3 P. M. all was in readiness and each one at his allotted post of duty ready for work. We were now surrounded by a clear, soft atmosphere without the slightest haze, and no trace of clouds except a small low bank on the western horizon. The temperature of the air was 71° Fahr.

2. *The Station.*

The station selected for us by Prof. Coffin was situate on an eminence known as South Hill in the south-west part of the town of Burlington. The enclosure was a level square of ground thickly covered with clover grass and surrounded by a hedge. It was elevated about 175 feet above the river, and its quiet and freedom from dust rendered it admirably suited to our purposes.

The accompanying plan, made under my direction, by Mr. Miles Rock, C. E., will show the plan of the building and the position of the instruments, observers and photographers during the eclipse.*

The latitude of our station in Burlington is 40° 48′ 21·58″ N. Longitude, 0 h. 56 m. 13·88 s. W. of Washington. It was about 7 miles north of the centre of the moon's shadow.

3. *The Equatorial and its Adjustments.*

The equatorial was borrowed from the observatory of the Central High School of Philadelphia, and is by Merz and Mahler of Munich. It is of 9 feet focus and 6·42 inches aperture and was mounted on one of Fraunhofer's wooden stands. It has a driving clock, the movement of which is governed by the friction of revolving arms against the inner surface of a cone, and by bringing the knobs (which terminate the arms and are attached to them by springs) to run against

* As this map was of large size and not essential to the understanding of any important point, it was not thought desirable by the Committee on Publications to have it engraved.—Ed.

a larger or smaller circumference of the cone we obtain a greater or less velocity of clock-movement.

The stand of the telescope rested on massive cross-timbers firmly rammed in the ground.

The object-glass of this instrument had a light brownish tinge, which it is important to remember, as it may have had some effect on the chemical action at its focus.

The probability of cloudy weather immediately preceding the eclipse, caused me to use the following method of adjustment; and it is well I did, for otherwise I should not have been able, in the few hours when the stars did appear, to have brought my telescope into the exact position I did.

I had the cap, which covers the object-glass, centered on a lathe and pierced with a hole. The object-glass and eye-lenses were removed and a plumb line was let fall from the hole in the centre of the cap through the hole of the cap of the occular. When the line was brought to the centre of the hole of the eye-cap, the axis of the telescope was vertical. The vernier was now read, the tube brought to a vertical position on the other side of the polar axis and the vernier read again. The difference of readings gives twice the angle formed by the vertical with the polar axis, and, if the polar axis is elevated to the latitude of the place, will equal twice the co-latitude of the station. If the angle obtained is too great, close it by elevating the polar axis, if too little, open it by depressing the axis.

I thus, assisted by Mr. Rock, adjusted the telescope to within 1′. The error read was 30″. I say within 1′, for 1′ on a radius of 9 feet is ·03132 inch, and a deflection of the line $\frac{3}{100}$ of an inch from the centre of the occular cap will give a deviation from *centrality* of *twice* that quantity, or $\frac{6}{100}$, (about $\frac{1}{16}$ inch); for we measure with the eye from the *sides* of the hole to the line and not from its centre to the line, so the difference of these measures is twice the deviation.

As stated above, the polar axis was brought as near as could be in one plane with the meridian line previously traced and the azimuth adjustment, tested in the following manner, required only a slight alteration.

To bring polar axis into the plane of the meridian.—Select an equatorial star and place micrometer thread so that the star glides along the thread when the telescope is moved in right ascension. The thread is now nearly parallel to the equator. Select a star about three hours off the meridian, say W., and bring it on equatorial

thread of micrometer and set the clock going. If the star, (as seen in a refractor with a direct eye-piece) *rises* above the thread, then N, end of polar axis, is E, of the meridian; if the star *falls* below the thread, then N, end of axis, is W, of meridian plane. If an E star is used, then the above rule is reversed (E for W, &c.)

After each adjustment the equatorial wire is reset to the equator, and the operations are continued until star neither rises nor falls.

On the night of the 6th—7th this adjustment was effected and the clock, after much trouble, regulated until it drove the tube so that a star was closely bisected for about twenty minutes. During the adjustment of the clock the precaution was taken to place the tube to about the same elevation it would have the next day during totality.

4. *The Camera and Chronograph.*

The image of the sun was formed on the plate of the camera by the action of a negative eye-piece, the lenses of which were so placed by Mr. Zentmayer in relation to the object-glass and to each other, that the diameter of the sun's image, on a $4\frac{1}{2} \times 5\frac{1}{2}$ inch plate, was 2·04 inches. This image was therefore not the direct image formed by the object-glass, but, according to De la Rue's plan, adopted and judiciously modified by you, it was the magnified image of the direct image which was used.

(*a.*) The adjustment of the reticule of the camera.

Mr. Zentmayer had so constructed the camera eye-piece that the image of a reticule of two spider threads, at right angles to each other, was formed on the plate with the image of the sun, and these threads were so mounted that they could be adjusted respectively parallel and at right angles to the celestial equator, and thus fix on the photographs the positions of the sun and moon, and give the position-angles of points on the surface and periphery of the sun. This adjustment I deemed of great importance, as without it we would not obtain the position-angles of contact nor the positions of the protuberances during totality. The lines are nearly as sharply defined on the pictures of totality as on those taken during partial phase.

The adjustment was made as follows: The camera was firmly screwed to the telescope and the focussing tube was moved until the images of the sun and threads of the reticule were brought to exact focus on the ground plate. The well-defined spot in the S. W. quadrant of the sun was now made to travel along the thread, by clamping the telescope in right ascension, and the reticule plate

revolved until the spot was accurately bisected during all its progress across the field. The telescope was then unclamped in right ascension (still remaining clamped in declination), and moved around the polar axis so that the spot ran along the thread; it was found to be bisected throughout all its transit.

Dr. Gould, at my request, now examined the adjustment and pronounced it precise.

(*b.*) The experimental determination of the time of exposure during partial phase.

The tube carrying the camera lenses screwed into a plate, in which, immediately in front of the anterior lens, was a guide in which a thin plate, having a horizontal slot of ·0224 inch in width, was caused to descend by the action of a spring.* Any integral ray of the beam whose rays successively passed this slot, traversed the plate only during the time it took the slot to fall its own breadth, or the ·0224 of an inch; and the determination of this time,—being the time of exposure,—has been the object of an experimental investigation which is given below.

During *totality* the full aperture of object-glass was employed and a slide-plate was used which had a circular opening, which allowed the full beam to pass. This plate had two falls instead of one as was the case with the ·0224 inch slide used during partial phase. On setting the plate free by the top trigger it fell, and the collodion plate was exposed to the entire beam; after the desired exposure a lower trigger was relieved and the plate made a second fall and, the lens being covered by the top of the plate, the exposure ceased.

After my examination of the photographs I realized the importance of an accurate determination of the time of exposure during partial phase, so that those who should hereafter attempt similar work might have the full benefit of our experience. This I considered all the more important because our results are apparently as perfect as any heretofore attained, and therefore *the time* which gave these results should be accurately known.

A reference to the diagram of the camera will render clear the method of registering on the chronograph and also the process by which I determined the duration of the flash of the sun which fixed his image on our plates.

During the eclipse the registration on the chronograph was ef-

* The construction was such that the plate could be made to descend by the action of 1, 2 or 3 springs; only one was used by me for the exposures of both partial phase and of totality.

fected as follows: A circuit passed from the face plate A B to the chronograph through the trigger K, and the spring attached to the binding screw L, which latter was insulated from the slide by being fixed to the wooden camera box. On tapping the trigger K, the pin, P, of the slide, being relieved of support, the slide fell, and the circuit was broken by the spring under the trigger no longer touching the top of the spring L. Thus a break circuit was obtained, at the instant of each exposure, which was duly registered on the chronograph.—(See Plate I., opposite.)

The arrangement of apparatus and circuit for the determination of the time of exposure was as follows:—

From the break-circuit clock of my observatory I led a wire to one pole of a battery, thence by the other pole to the plate at H; from this plate the current went through the trigger K and spring at L to a Morse register; from the register by a wire which led back to the clock and thus completed the circuit. Another short stiff wire, O A, was attached to the binding screw L, and reached from L to a short distance beyond the slot, A, and was in front of the surface of the face-plate, A B, but so near to it that when the slide fell, the projecting pin, P, would strike the wire about $\frac{1}{10}$th of an inch above its lowest point of fall.*

Now, suppose the projecting pin P to rest on the trigger K, while the spring under the trigger rests on the top of the steel spring attached to L, and that a paper fillet is running through the Morse register; then at every second the clock will for an instant open the circuit and there will be a very short break made in the line marked by the pen on the fillet, and thus the seconds of *time* are stepped off in *space* on the paper ribbon. Suppose now that the long end of the trigger K be sharply driven by the blow of a hammer against the face of the camera; the circuit will be *open* during the fall of the pin from the top of the trigger to the point where it strikes the wire, O A, projecting from L, and there will be produced in the line on the fillet *a break*, whose length compared with the length of the second in which it occurs will give the time required for the plate to fall the above mentioned distance. It is evident that as soon as the pin strikes the wire the circuit is again closed, and the clock breaks the circuit as before the fall. I always struck the trigger at about a half second so that the comparison could be readily and accurately made.

* The wire, O A, is represented in the engraving, bent upward at its end, A; it should be straight.

We have given an engraving of a fillet, which shows the break at the seconds and during the fall of the plate.

The fall being accurately measured and the time of that fall known, the time the plate takes to fall ·0224 inch, which is the time of exposure, can be accurately computed.

Before giving the results of these experiments I should remark that the plate descends with an increasing velocity produced by the action of the decreasing force of the spring, and what I obtained was the mean velocity of the plate. Also, the time it took the pen of the register to leave the fillet at demagnetization and to return to the fillet at magnetization is neglected, and as I had no means of determining it I adjusted the force of current and of spring so that these motions were as rapid as possible. I do not think the time required for these motions has affected the results appreciably, especially as the fall was a large multiple of the breadth of the slot.

The breadth of the slot was measured under the microscope and the mean of three measures, at ends and middle, gave ·0224 inch.

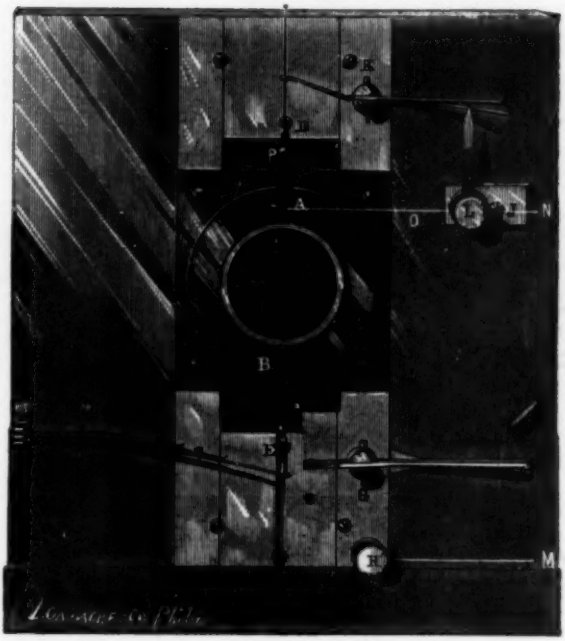
As an example of the manner of determining the time of exposure from the above data we will take the results of Fillet No. 1.

Length of second on fillet,	·83	inch.
" break during the fall of slide	·105	"
Fall of slide	1·340	"
Width of slot in plate	·0224	"

$\frac{\cdot 105}{\cdot 83} = 0{\cdot}126 =$ time of fall of slide through 1·34 inch.

$\frac{\cdot 126 \times \cdot 0224}{1{\cdot}34} = \cdot 00211 =$ time of exposure.

No. of Fillet.	Length of 1s. on Fillet.	Length of break on Fillet during fall of Plate.	Fall of Plate.	Time of Exposure.
1	·830 inch.	·105 inch.	1·34 inch.	·00211 second.
2	·765 "	·090 "	1·34 "	·00196 "
3	·790 "	·0975 "	1·34 "	·00205 "
4	·795 "	·100 "	1·34 "	·00208 "
5	·840 "	·120 "	1·34 "	·00237 "
6	·785 "	·095 "	1·34 "	·00202 "
7	·755 "	·110 "	1·36 "	·00231 "
8	·860 "	·120 "	1·36 "	·00228 "
9	·750 "	·100 "	1·36 "	·00211 "
Mean time of exposure.....				·00214 "



INSTANTANEOUS EXPOSURE SLIDE.

Fall of Slide 1·34 inch.

S S FALL S S

COPY OF FILLET No. 5.

The greatest departure in these results from the mean is ·0002. No. 2 being that quantity below, and No. 5 that amount above the mean.

The sum of the last column of figures equals 39; their mean 4·33; which shows that they are entirely of an arbitrary value, and if the experiments had been extended would no doubt eventually have equalled 4·5; we therefore reject the last decimal place, and adopt for our final result ·0021 of a second. The time of exposure was therefore almost exactly $\frac{1}{500}$th of a second!

5. *The work during the Eclipse.*

As before stated, by 3 P. M. of August 7, all was in readiness for our work. Mr. Willard had used every precaution to ensure success in the details of photographic manipulation, and the results which he reached will show with what judgment and skill he had organized all the workings of this department. The accompanying plan shows the position of our party, and also of Professors Coffin, Gould and Young during the eclipse.

It was my duty (2 on plan), to keep the telescope in adjustment, and to manipulate the apparatus of exposure and chronographic registration, while Mr. Willard (5) placed the plate in the camera and gave me the several times of exposure he desired during totality. Mr. H. C. Phillips (7) coated the plates and handed them to Mr. Montfort (photographer of Burlington), who carried them to Mr. Willard, and thence after exposure to Mr. Mahoney (8) who developed, assisted by Mr. Leisenring.

The plan shows the exact dimensions and position of the photographic rooms, and needs no description to render it clear.

M. Miles Rock, C. E., was detailed to attend to the very important duty of calling and tapping the seconds on the chronograph fillet; in this duty he was relieved by Mr. Bonsall, of Burlington. Mr. O. H. Kendall called out the minutes, at each 60 second call of Mr. Rock, and wrote it on the fillet. He also had charge of the chronograph, and started it when I called "clock," while at the same signal, Mr. Rock began the registration of seconds.

I laid out the following programme of work:—1st. To take in rapid succession, beginning ten seconds before the computed time of first contact, a series of five photographs. 2dly. One just before second contact, one just after second contact, as many as possible during totality, one just before the end of totality, and another just

after the sun appeared. 3dly. To take again a series in rapid succession about the end of the eclipse. 4thly. During partial phase to take a photograph every four or five minutes.

To accomplish this, I placed on a table before me, a watch set to the face of the chronometer, whose indications we used during the eclipse, and on a slip of paper pasted to the table, I wrote in very black lead-pencil the computed times of 1st, 2d, 3d and 4th contacts. These I obtained from Professor Coffin. I thus could give Mr. Willard due notice when the plates should be prepared.

When the face of the chronometer marked 12 h. 48 m., Mr. Rock began to count and register the times on the fillet. Every one was at his post, the lanterns lighted, and nothing could be heard but the count and the tap of the chronograph. At 12 h. 49 m. 45 s., I took the first photograph, and following at intervals of 11, 10·8, 15·2 and 12 seconds, we secured five perfect photographs. The contact is first visible on the third. We now leisurely took photographs at intervals of about four minutes, until we had taken twelve plates in all. The moon's limb had now advanced to about three minutes of time of the spot in the S. W. quadrant. Professor Young, of Dartmouth College, who was stationed near me, stated his intention to signal as soon as the umbra was bisected by the border of the moon. The plate was prepared and all was ready. Professor Young signalled, I tapped the trigger; he remarked, "you must have shot it on the wing." The 13th plate (No. 15), shows the spot as nearly cut in half as I can estimate, by a careful comparison of this drawing with another of the spot, as photograped on the preceding plate.—(See Plate III.)

About five minutes before totality, Mr. Willard removed the diaphragm of two inches aperture, which was used during partial phase, and exposed the full aperture of the object glass, while I changed the slide with ·0224 inch slot for the one which admitted the whole beam at once on the plate of the camera.

The order was given to prepare the plates. We took the first plate at 13 h. 51 m. 39·15 s., or 7 s. before the time of second contact, as observed by Professor Coffin. I soon had the slide reset for another exposure, and as Mr. Willard desired the first plate of totality to be exposed five seconds, I kept on counting zero, zero, zero, with the taps of the chronograph when, striking the upper trigger at zero, I counted 1, 2, 3, 4, 5, when the lower trigger was struck and the plate removed.

Counting the first plate, taken seven seconds before second contact, I took six photographs in 2 m. 3 s. After the sixth was removed, I looked at watch and saw 50 s. yet of total phase. There was a delay in the plate. I grew impatient. I called plate! plate!! but alas, it was found impossible to manipulate more than six plates in two minutes and three seconds. We had used up our store too rapidly, and so did not succeed in getting an impression just before the sun came forth. The next plate was taken 29·2 seconds after third contact, and is a valuable photograph of a thin crescent with the cusps sharply cut.

As has already been explained, under the head of camera, at each fall of the slide, the electric circuit was broken, and a registration made on the fillet alongside of Mr. Rock's second marks taken from the chronometer, and it is evident that all of these registrations are vitiated with whatever personal equation affected him at that time. This was not determined.

About fifteen minutes before totality, it became so cool that I was obliged to put on my coat. A minute or two before totality, the sky grew ashen, or rather leaden in hue, and as, with face turned towards the sun, I kept the count from the chronometer for the first exposure, Venus and Mercury came out shining beautifully on a ground of bluish grey. I thought I saw a flashing twirling motion in the corona, or in the last rays of the sun; but of this I will not be positive, for my attention was not, at the time, specially directed to minute observation. Moths and insects in profusion passed between me and the sun, while a flock of birds with troubled irregular flight seemed seeking cover from the unnatural gloom which surrounded them. A low moaning wind now sprung up, and the whole atmosphere seemed filled with a leaden colored vapor, and I experienced an indescribable feeling of oppression when—I tapped the trigger; and from that instant until the sun appeared, I had nothing but an *instrumental* consciousness, for I was nothing but part of the telescope, and all my being was in the work which I had to perform. I reset slide, made circuit, exposed, and so over again, until the six photographs were taken, when I had the mortification to find fifty seconds of totality, and that no plate could possibly be obtained; we were *too* quick.

Photographs were now taken leisurely, at intervals of about four minutes, until 14 h. 47 m. 48·4 s., when the first of the series for the end of the eclipse was secured; this was followed by four others

at intervals of 1 m. 16·84 s., 29·26 s., 24·3 s., and 21·55 s. Our work was finished, and in a few seconds the eclipse of August 7th, 1869, was of the past, but its history we had faithfully recorded in forty-one perfect photographs.

Such good success as attended our efforts speaks for the entire devotion of each one to his allotted duties. Without this devotion on the part of each and all we would have failed, and the harmony and efficiency which pervaded our corps need no other witness.

6. *Description of the Photographs taken.*

We took four photographs during the eclipse. They are all good, but some are superior to the others, and these will be designated as I proceed.

The plates were numbered with a diamond before the work began, and the numbers corresponding to those on the plate are given below, and opposite them the times when they were severally taken. These times were measured off from the chronograph fillet, and correspond to the face of the chronometer, which marked Burlington sideral time, with an error of 11 m. 58·3 s. slow.*

No. of Plate.	Time when Taken.		
2	12 h.	49 m.	45·25 s.
3	12	49	56·
4	12	50	5·8
5	12	50	21·1
6	12	50	32·95
8	12	53	5·3
9	12	56	3·2
10	12	57	33·4
11	12	59	17·6
12	13	2	18·1
13	13	7	23·3
14	13	12	19·27
15	13	15	14·24
16	13	22	57·5
17	13	20	55·6
18	13	32	58·0
19	13	37	41·5
20	13	41	50·6
21	13	46	34·1
22 (5 s. exposure)	13	51	39·15
24 (5 s. ")	13	52	3·1
25 (7 s. ")	13	52	31·3
23 (7 s. ")	13	52	54·5

* 1869 August 7. 12 h. Sid. T. + 11 m. 58·30s. slow.
Daily change..... + 5·55 s. loses.

No. of Plate.	Time when Taken.		
26 (7 s. exposure)	13 h.	53 m.	12·37 s.
27 (7 s. ")	13	53	42·2
28	13	55	1·2
29	13	57	20·5
30	13	58	5·5
31	14	2	41·0
32	14	7	14·67
33	14	11	33·5
34	14	16	59·6
35	14	23	1·5
36	14	29	21·5
37	14	36	33·5
38	14	44	33·1
39	14	47	48·4
40	14	49	5·24
41	14	49	24·5
42	14	49	48·8
43	14	50	10·35

All the photographs show a beautiful gradation of shade from the border of the sun inwards. This *shading of the source of light* is due to the absorption of the peripheral rays which necessarily pass through a greater thickness of the dense solar atmosphere than those which emanate from the central portion of the disc.

On a more searching examination of the relative intensities of light of different portions of the solar disc, we observe on all of these photographs, close to the limb of the advancing or retreating moon, a bright glow like that of early dawn, which extends from the moon to a distance of about 15″.

Thinking that this might be subjective and due to the strong contrast existing between the bright image of the sun and the contiguous black lunar disc, I made the following experiments.

I covered the image of the moon with a disc of white paper of its exact diameter. The plate was now inclined to the light so that the sun and the paper surface had as nearly as possible the same white tint, while the photograph was viewed against an illuminated ground formed by a sheet of white paper, placed before the window. Under these circumstances, the glow remained the same in all the photographs examined. Among others, plate No. 11 (which is the best photograph of partial phase in the series), shows this glow unequivocally.

Plates Nos. 21 and 30, are excellent photographs of thin crescents of the sun; the first taken 5 m. 12 s. before, and the second

3 m. 33·5 s. after totality. This glow, if it really exist, should show in these pictures an increased illumination in the points of the cusps when the light of these portions of the periphery of the sun is compared with an equal breadth of the sun's border, taken on that portion of its limb the farthest from the moon's. To make this comparison, I covered with white paper both the moon and the dark ground surrounding the sun, and inclined the plates as in the above experiments, so as to destroy irradiation from juxtaposition of the light and dark surfaces. This method of examination showed a distinct illumination in the narrowest portions of the horns of the crescents.

No such glow is seen on the periphery of the sun, although this is contiguous to the dark ground of the plate, and on covering the latter the appearance remains the same.

I am therefore convinced that this glow really exists, and if it cannot be accounted for in node and in *measure*, by diffraction, it must be due to a lunar atmosphere; though, I confess, I cannot understand how an atmosphere capable of producing such marked effects, when projected against the intensely lighted disc of the sun, should have no appreciable refractive effect on small stars, and especially on double stars, when occulted by the moon.

This glow can be distinctly traced on plate No. 11 to 18″ beyond the limb of the moon.

A minute examination of these photographs reveals a coarsely granulated or mottled surface extending over the sun, and especially well defined as we near its border. One is tempted at first to imagine that this is the well known solar granulation observed in the telescope; but familiarity with that appearance, as well as the reasons given below, soon decided me to reject the idea that this appearance on the photographs was really an impression produced by the image of the sun's granulation on the plate.

First, the granulations are many times larger than any ever yet observed; those on the photographs averaging 7·5″ in diameter, while those on the sun average 1″, and never exceed 3″ in diameter; 2dly, on plate No. 14 the mottling is very apparent, and encloses a space entirely free from granulation in the N. E. quadrant; no corresponding vacant space occurs in any of the other photographs; 3dly, the positions of these granulations are not the same on any two plates, as I found from very careful measurement; and 4thly, they are arranged in rows parallel to the sides of the plates, thus

showing conclusively that they have been produced in the photographic manipulation.

According to the photographs, sixteen well defined solar spots were on the sun during the time of the eclipse. In the N. E. quadrant, close to the sun's limb, and about 90° E. of N. is a remarkably beautiful and characteristic spot, greatly foreshortened from its position, so that the penumbra has disappeared on the west side of the umbra against which rest the large bright faculæ, which enclose the spot. Looking at it through a lens, you are immediately struck with the idea of a depression in the sun's surface, and you cannot help remarking how like it is in appearance to a lunar crater, for you are convinced that you look down *into* it, while the surrounding bright faculæ give a border similar to the white walls of some of the lunar mountains. From the south-western portion of this apparently elevated ridge, a large bright facula bridges over the cavity in a north-east direction, and divides the spot into two portions.

Plates Nos. 11, 16 and 21 show this object in perfection.

In the S. E. quadrant, we see three small and well defined spots, and several largely developed faculæ near the sun's limb.

In the S. W. quadrant is a large and well-developed spot, and near it, to the N., a group of four smaller ones. This large spot exhibited remarkable changes during the time of the eclipse, as will be seen from the drawings and measurements found under the head of "Measurements on the solar spot in the S. W. quadrant."

On close inspection, there is observed a very white projection from the surrounding bright surface of the sun, which stretches into the north-western border of the penumbra of this spot and reaches nearly to its numbra.

In the N. W. quadrant no solar spots are visible on the the photographs. About N. N. W. of the intersection of the threads of the reticule are observed what, at first sight, we might take for a group of spots, but they are specks of dust on the lens of the occular, as they change their place on the disc with the threads, always preserving the same position in reference to them. This test will serve to distinguish other spots on the photographs, produced by the same cause—as, for example, the four spots on the S. E. quadrant.

Plate No. 4, which, fortunately, is one of the best photographs,

was taken 2·8 seconds after first contact, as observed by Dr. Gould. It shows a depression in the sun's limb at the point of contact, and from this depression shoots into the sun a high lunar mountain, whose position, measured from the S. point of the cusp, is one-fourth of the distance to the N. point of the same. Mr. W. S. Gilman, of New York, who observed at Sioux City, Iowa, informed me that he determined first contact by seeing this mountain peak thrust itself into the limb of the sun before a flattening took place from contact of the lower general surface of the moon. This mountain shows itself on all the photographs of the eastern limb, while other peaks appear as the moon progresses over the sun. The photographs show that the eastern limb of the moon is far more mountainous than the western.

Plates Nos. 4, 9 and 11, best show the mountains on the following limb; plates Nos. 31, 35 and 42, on the preceding limb.

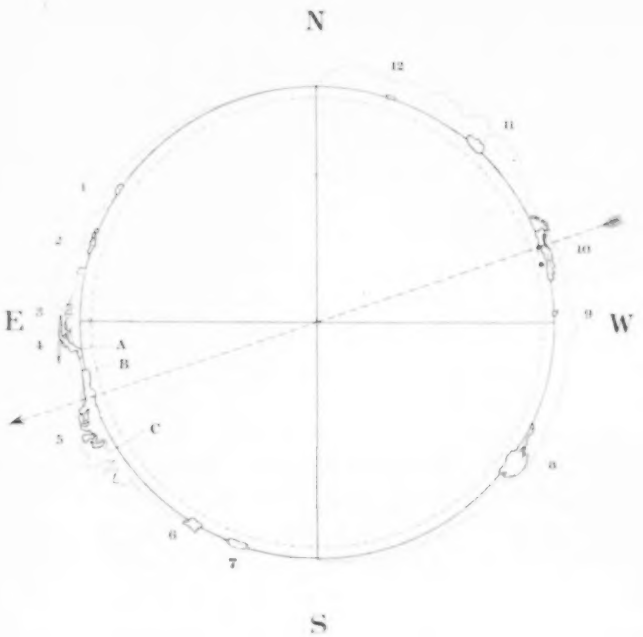
The best method of examining these mountains is to cut with a sharp knife a disc of paper of the exact diameter of the image of the moon, and make its circumference coincide with the general level of the moon's periphery; the lunar mountains will then appear as black protuberances rising above the white circle of the paper.

Plates Nos. 39, 40, 41, 42 and 43, taken in rapid succession, as the moon was leaving the sun's disc, previous to fourth contact, show two prominent lunar mountains on the northern part of the cusp, followed by a long depression in the moon's limb.

Five photographs were taken during total eclipse, and one 6·85 seconds before, and one 29·2 seconds after totality. The one (No. 22) taken 6·85 seconds before the disappearance of the sun, shows all the prominences of the eastern limb; but on account of the long exposure, the thin crescent of the sun which then remained, caused a blurring of the details. The picture is a mixture of crescent and protuberances. The prominences, 6 and 7, are entirely isolated, while the intervening ones are enveloped in the light of the crescent.

Plate No. 28, taken 28·2 seconds after totality, is the photograph of a very thin solar crescent, whose cusps are sharply defined throughout. The northern horn is narrower than the southern, which causes the moon's disc to appear to depart from a circle curve.

No. 24, taken at 13 h. 52 m. 3·1 s.—that is, 17·1 seconds after totality, shows the full development of the prominences on the



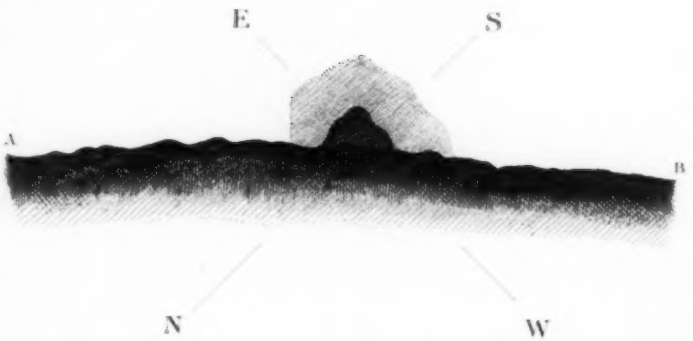


Plate 15.

13 h. 15 m. 14 s. 24.

eastern limb, while on the western only the top of the large southern protuberance (No. 8) is visible, and a slight glow appears on the N. W. and S. W. border.

Nos. 25, 23, 26 and 27, taken respectively 45·3 seconds, 1 m. 8 s., 1 m. 26·37 s., and 1 m. 56·2 s. after the disappearance of the sun, show the advance of the moon westward, and the gradual appearance of the prominences and glow on the western limb, while those on the eastern are being gradually cut off from view.

In No. 25, protuberance No. 8 is yet alone visible, while the glow appears along all the western border of the moon. Protuberances 1 and 2 are covered by the moon.

In No. 23, the glow on the western limb is about equal to that on the eastern. The tops of protuberances 10 and 11 are just visible, while 7 is just fading from sight.

In plate 26, on the western limb, prominence Nos. 9 and 12 have not yet come into view; No. 8 has already taken the form of the albatross head; No. 10 only appears like a grain of rice set on end; while No. 11 resembles two such grains standing on end near each other. The glow is now greatest on the western limb.

In plate No. 27, taken 40 seconds before the sun came forth, we see No. 8 as a fully developed albatross head with bill and throat close to the moon's border.

The small protuberance No. 9 now comes in view, and No. 10 assumes the shape of a caterpillar; 11 appears as a grain of wheat with a groove around its middle, and No. 12 comes in sight. On the moon's eastern border a mere trace of 6 appears, while 4 exectly resembles a bird sailing close to the surface of the moon. The group of protuberances, No. 5, which formerly appeared high above the body of the moon, floating in cloud, now rest upon its border.

This sketch will, I hope, give a general idea of the development and disappearance of the several flames, and show how rapid was the shifting of scenes during totality. All the changes I have described took place in 1 minute and 39·1 seconds, the time in which the five photographs were taken.

The accompanying diagram has been very carefully drawn from the results of measurements and calculations on the position-angles of the prominences.

I wish it to be understood that all of the measurements on the photographs given in this preliminary report were made on *copies* on glass, and not on *the original negatives;* also, that no microme-

tric apparatus was used, but only an accurate scale divided into half millimetres, the readings on which were made with a lens. These numerical results (except those of the position-angles and heights of the protuberances) are therefore only approximative, and the numbers to be used in a thorough discussion of the eclipse will be given as soon as accurate micrometric measurements can be made on the original negatives.

The protuberances are designated by numbers, from 1 to 12, going from N. through E. to N. The position-angles and heights are tabulated under the head of "Results."

The drawing and measurements of the prominences on the E. limb of the sun are from the first photograph taken, while those on the W. are from the last picture obtained. The diagram therefore shows the greatest visible development of these objects on the eastern limb, and those on the western are as they appeared 40 seconds before the end of totality.

Proceeding from the N. by the E. we perceive a glow of light which begins a little E. of N., and extends nearly to the S. point. This luminous fringe to the photograph (represented on the diagram by the irregular dotted line) reaches its maximum height about midway between prominences 2 and 4, there attaining an elevation of 2′ 15″. Another maximum of altitude occurs a few degrees S. of No. 5, where it has the same height. In the midst of this bright glow and near its greatest height appears at 3 and 5 detached sheets of bright flame floating above the lower mass of the conflagration.

The bases of the other protuberances are on the periphery of the moon, and *all* except No. 4 rest *below* the general circle of the moon's border. This appearance is *partially* explained by the fact that the telescope follows the motion of the protuberances, while the moon, therefore, has the difference of angular velocity between it and the sun. At the instant of exposure the portion of the prominence resting against the moon's limb is photographed; but, as the moon moves eastward during all the time of exposure, the prominence will appear as a *depression in the moon's limb*, for the latter has moved to a higher portion of an eastern prominence, and to a lower portion of a western, by the time the exposure is ended.

From the relative motion above referred to, it must necessarily follow that the border of the moon will not be well defined; but the eastern one will be more sharply cut than the western. All of the photographs of totality show this distinctly.

On plate No. 26, the apparent depression of prominence 11 is nearly all due to its being in the hazy limb; its base resting in a very slight depression.

The amount of depression of the prominences I have accurately represented in the accompanying diagram.

Proceeding from the north point to the east, we first meet with prominence No. 1, having the position-angle of about 56° 30′. It is of the shape of a rice grain, with its base but slightly below the circumference of the moon. In breadth it is 2° 50′ and in height 22″. As 1′ on the circumference of the sun equals 124 miles and 1″ of arc at the sun's distance, on August 7th, subtends 449 miles, it follows that its actual dimensions are 21,000 miles long, and 9,900 miles high.

Protuberance No. 2 lies imbedded in the moon's border, and has in form the appearance of a short, deeply articulated worm. Its mean position is 69° 17′; its length 6° 17′, or 46,700 miles, and its greatest height equals 22″ or 9,900 miles.

Between protuberances Nos. 2 and 3, are two flames in the midst of the glow previously described; one, near to No. 2, the other quite close to No. 3. Midway between Nos. 2 and 3 rises the diffused light to an elevation of 2′ 15″ or 60,500 miles. The position of protuberance 3 is 87° 15′ and it rises to a height of 1′ 15″ or 33,600 miles.

We now come to that curiously formed protuberance No. 4. Some have compared it to an ear of corn, but on the photographs it appears like an eagle, with outspread wings, resting on the trunk of a tree, which leans towards the north. On plate 27, where the tree stump is cut off by the advancing moon, the resemblance to an eagle on the wing is perfect.

The form of this object indicates instability, and impresses one with the idea that it is a great travelling whirl of flame, the direction of whose rotation—as indicated by the position of "the wings" and the projection of one on the other—is retrograde or in the same direction as the motion of the hands of a watch. I have examined with care the successive photographs of it, and although at first I thought that the last impression differed from those preceding, in that the wings had become longer and more in a line with each other, yet, on subsequent examination, I could not really decide that a perceptible motion had taken place during the time of totality.

The position-angle of the north side of the base of this object is

96° 25′; its height is 1′ 22″ or 36,700 miles, and the spread of the wings, as measured on plate 27, is 9° 31′, or 70,800 miles.

Protuberance No. 5 reaches from B to an ill defined point beyond C of the diagram; it is of very irregular outline, and shows portions of its substance detached from the general mass, and floating freely above it. The most elevated and bright of these detached flames float at a height of at least 20,000 miles above the surface of the sun.

Beyond the point C, a white nebulous cloud rises to the elevation of 2′ 15″ or 60,500 miles.

Protuberance No. 6 of the diagram has a mean position of 148°; its length is 3° 5′ or 22,900 miles, its height is 45″ or 20,000 miles.

The position of the centre of No. 7, shaped like a grain of wheat, is 159° 22′; its length 5° 13′, equal to 38,800 miles, its height 37″ or 16,600 miles.

We now pass to the western limb of the sun, and meet with the remarkably large and massive protuberance No. 8. It is shaped like an albatross head, with the beak and under side of the head resting on the limb of the moon. On a photograph taken at Ottumwa, Iowa, just before the sun came out, this protuberance had the exact appearance of an albatross head, with the beak open, holding a rounded mass between the extremity of the jaws. It lies between the position-angles of 230° 13′ and 245° 46′; its length is 15° 33′, or 115,700 miles, and its greatest height is 75″ or 33,600 miles.

The small prominence, No, 9, has a position of 273° 27′.

Protuberance No. 10 bears the most striking resemblance to a caterpillar. Its mean position is 287° 33′, and it extends through an angle of 11° or 81,800 miles. Its maximum elevation, which is at the head of "the caterpillar," is 52″ or 23,300 miles. Out of the head issue two horns; the one nearest the front being the higher of the two, and is terminated with a knob or ball, from which curves a broken line of light to the border of the moon.

The centre of prominence, No. 11, has a position of 318° 33′ and its extent is 5° 18′ or 37,400 miles, with an elevation of 44″ or 20,100 miles. It has the shape of a grain of rice, slightly constricted in the middle.

The small protuberance, No. 12. has a mean position of 343°. Its length is 1° 51′, or 13,800 miles, and its greatest height is 15″ or 6,700 miles.

The faintly dotted circle, inside the circumference of the moon, shows the relative diameter and position of the sun at the middle of total eclipse. The scale on which the diagram is made fails to show want of coincidence of the centres of these circles. The arrow marks the points of contact, and shows the direction of the motion of the moon.

7. *Results.*

Under this head, I give a few approximate results deduced from measurements on the glass positives; it being useless to attempt more until an accurate micrometric apparatus is brought to bear on the original negatives.

(*a.*) The time of first contact.

This determination was made by taking the mean of several measures of diameters of the sun's image on one of the plates, and from the known angle subtended by the moon deducing its diameter in the same unit of length; then the chord of the cusp was measured, and from these data the distances of the chord from the limbs of the sun and moon (or the versed sines,) were calculated.

From the known hourly motion of the moon (allowance being made for parallax), we obtain the time of first contact.

It is evident that if this measure be accurately made on the negatives, and the effect of refraction be also taken into account, we have precise data for determining the corrections necessary to be applied to the elements of the eclipse.

The time of first contact thus deduced from two plates, gave 12 h. 50 m. 2·94 s., which is 1·1 second before contact, as observed by Professor Coffin, and 0·1 second before Dr. Gould's observation. From measures on another plate (No. 5) we deduced 12 h. 49 m. 59 s., which is 4 s. before contact, as observed by Dr. Gould, and $\frac{6}{10}$ of a second after contact, as determined by Prof. Young with his new spectroscopic method of observation.

(*b.*) Position-angles of first and fourth contacts.

These position-angles we determined on plates 8 and 41, from the following measures.

Plate No. 8. Radius of sun = 31·4. Length of ½ chord from N. point to point of contact = 18·25.

$$\frac{18{\cdot}25}{31{\cdot}4} = {\cdot}5793 = \text{sin. } 35^\circ\ 24'; \times 2 = 70^\circ\ 48'$$

Hence angle of first contact is $-70° 48'$ or $+289° 12'$
Computed angle - - - $= -71°$

Difference - - - - - - - $-0°12'$

Plate No. 41. Radius of sun = 30·835. Length of $\frac{1}{2}$ chord from S. point to point of fourth contact = 18.

$$\frac{30{\cdot}835}{18} = {\cdot}5837 = \text{sin. } 35° 43'; \times 2 = 71° 26'$$

Position-angle of fourth contact = $108° 34'$
Computed angle - - - - $= 108° 0'$

Difference - - - - - - - $= +0° 34'$

The points where the inner dotted circle of the diagram is cut by the arrow, shows the positions of contact as determined from the photographs.

(c.) Position-angles and heights of the protuberances.

The determinations of the position-angles and heights of the protuberances on the eastern limb of the moon are derived from measures on plate No. 24, the first taken during totality, and those on the western limb, from No. 27, the last plate of totality.

The measures were made in the following manner: On plate 24, only the reticule line on the eastern border is visible; but on plate No. 25, taken 28·2 seconds after, both eastern and western lines are sharply cut; and prominence No. 6 is nearly as fully developed on this plate as on that just preceding. I therefore obtained the exact angle of position of the south side of prominence 6, on plate 25; then, from this position, as point of origin of chords *on plate 24*, I determined the positions of prominences 4, 5, and 7. As the chords drawn from the south side of prominence 6 to protuberances 1, 2 and 3, were too long to give accurate determinations from their measures, I fixed the position of these prominences from measures made from the north side (point B.) of protuberance No. 5, previously determined by reference to the south side of prominence No. 6.

On plate No. 27, the reticule line on both eastern and western limb is distinctly photographed, and so this plate was alone used in determining the positions of the western protuberances.

The measurements were made on glass positives, taken directly from the original negatives by means of an orthoscopic lens, which enlarged the moon's image to a diameter of 2·47 inches. The

plates, firmly held by a wooden clamp, were supported about six inches above a board covered with white paper, and placed before a large north window. Sometimes the plates were parallel to the board, at others inclined, with the angle opening towards the window. This, I found, was the best illumination with which to examine the details of the photographs and to make measurements thereon. The legs of finely-pointed dividers were clamped to the proper opening, and with this radius arcs were struck, (cutting through the dark film of the photograph to the glass below,) having as their centres the points on the moon's border cut by the declination line of the reticule. Through the intersections of these arcs, a line was carefully drawn, which gave the diameter of the moon's disc which joined the N. and S. points of its periphery. Chords were now measured from the N. and S. sides of each protuberance to either the N. or S. points of position, according as the protuberance was in the N. or S. semicircle. Half of a chord being the sine of half the angle required, we can—having previously obtained the moon's radius—deduce therefrom the position-angle.

These measures have been made with the greatest care, and can, I think, be relied upon as accurate determinations. We do not think that, in this case, subsequent micrometric measures will add to their precision, for, from the difficulty of defining the exact boundary of the moon, (especially on plate No. 24,) the accuracy of the determinination of radii will not be increased by attempting a micrometric measure of what we cannot see.

In the measurements a finely-divided millimêtre scale was used, and the readings were made through a lens magnifying eight diameters.

The adopted radius of the moon, on each plate, is derived from the measures of four diameters, inclined 45° to each other. Every chord used is the mean of three measurements.

The measures, in millimêtres, serving as data for the position, are as follows:—

Plate No. 29—second of Totality.

No. of Measure.	Diameter of Moon.	
1	66·4	
2	66·0	
3	66·2	
4	66·2	
Mean diameter	66·2	R = 33·1
From S. point to S. side of prominence No. 6		= 17·4
Length (measured on plate 24) " "		= 1·8

Plate No. 24—first of Totality.

No. of Measure.	Diameter of Moon.
1	66·3
2	66·1
3	66·25
4	66·3
Mean	66·24 R = 33·11

S. side of prominence	6	to	N. side of prominence	7	=	4·2
"	"	"	S. "	"	7	= 7·2
"	"	"	N. " (point B)	"	5	= 27·0
"	"	"	S. " (point C)	"	5	= 17·65
"	"	"	N. " of base of	"	4	= 29·6
"	"	"	S. " "	"	4	= 28·75
N. side (B)	"	5	to tip of S. wing of "eagle"		4	= ·7
"	"	"	" N. " "		4	= 6·2
"	"	"	" to centre of prominence		3	= 8·15
"	"	"	" S. side of	"	2	= 16·6
"	"	"	" N. "	"	2	= 20·0
"	"	"	" S. "	"	1	= 24·5
"	"	"	" N. "	"	1	= 26·0

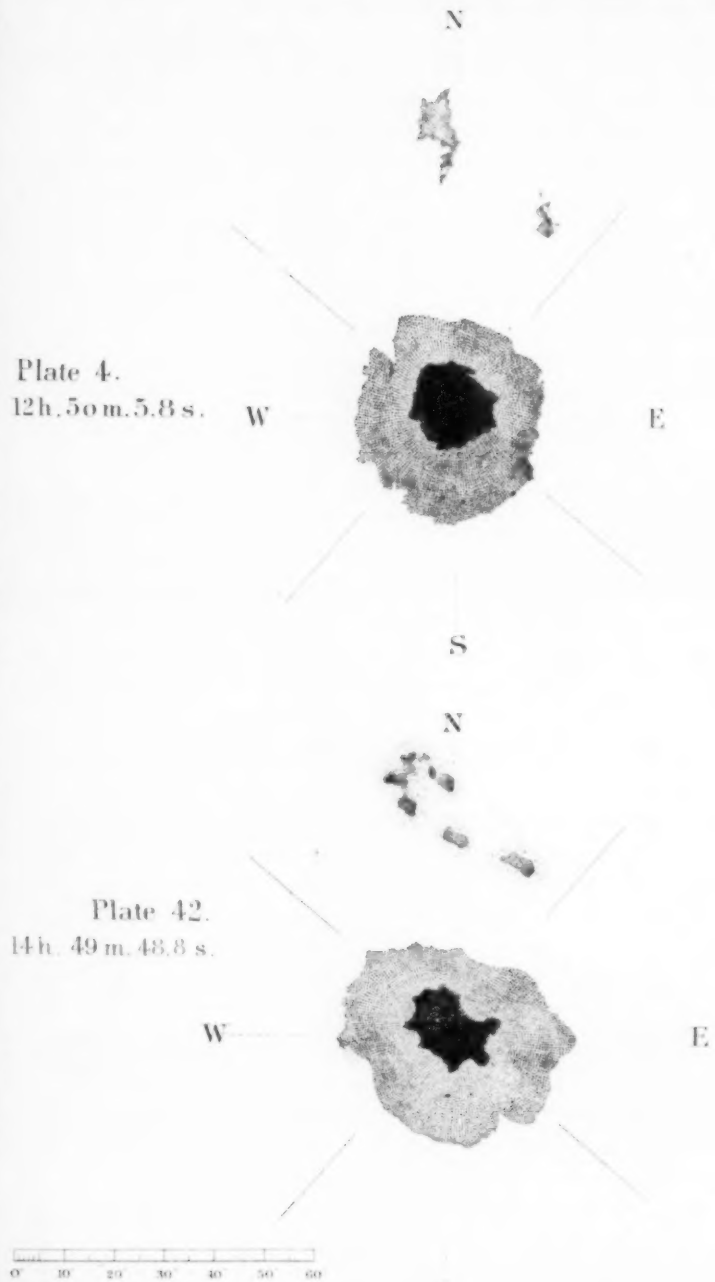
Plate No. 27—the last of Totality.

No. of Measure.	Diameter of Moon.
1	66·1
2	65·9
3	65·75
4	65·9
Mean	65·94 R = 32·97

S. point	to	S. side of prominence	8	=	28·5
"		N. " "	8	=	35·8
N. "		centre "	9	=	45·2
"		S. side "	10	=	41·4
"		N. " "	10	=	36·3
"		S. " "	11	=	24·75
"		N. " "	12	=	10·25
"		S. " "	12	=	9·2

Table of the position-angles and heights of the Prominences.

No. Prominence.	Position-angles.	Height.
1	55° 9′ to 57° 59′	22″
2	66° 14′ to 72° 21′	22″
3	87° 15′	75″
4 (base of)	96° 25′ to 98° 4′	82″
4 (tip of N. wing)	90° 39′	
4 (tip of S. wing)	100° 10′	
5	101° 23′ to 118° 36′	136″ (nebulous cloud.)
6	146° 25′ to 149° 30′	45″
7	156° 46′ to 161° 59′	37″
8	230° 18′ to 245° 46′	75″
9	273° 27′	
10	282° 13′ to 293° 12′	52″
11	315° 54′ to 321° 12′	44″
12	342° 7′ to 343° 58′	15″


N
Plate 4.
12h. 50m. 5.8s.
W
E
S
N
Plate 42.
14h. 49m. 48.8s.
W
E
S
0' 10 20 30 40 50 60
1" on drawings = 0.27 inch.
1" on the Sun = 449 miles.

As the moon glides over the solar disc, the angle of position of any protuberance, referred to the disc of the moon, is constantly changing, and the amount of displacement depends on its position in reference to the line of the moon's motion.

The position-angle of the S. side of prominence 6 was first determined on plate No. 25, and this point, thus determined, was taken as origin of chords on plate No. 24, taken 28·2 seconds before; but I find by computation, that the position-angle of the S. side of prominence 6, on plate 24, is 32′ 32″ N. of what it is on plate 25; assuming, in the computation, that the prominence is stable in form and position on the sun's circumference. Therefore, it follows, that the position-angles of prominences 1, 2, 3, 4, 5, 6 and 7, as given in the above table, should be diminished by 32′·5 to make them correspond to the position-angles they had at the time plate No. 24 was taken.

(*d.*) Measurements on the solar spot in the S. W. quadrant.

The drawings marked "Plate 4" and "Plate 41," were made with a camera lucida, the spots being magnified under the microscope to exactly 21 diameters. They show better than can be described the changes which took place in the dimension and form of this spot in the interval between the times of 12 h. 50 m. 5·8 s. and 14 h. 49 m. 48·8 s. Through each spot two lines are drawn, in the directions of the minimum and maximum diameters of the spot on plate 42. The lines on 4 are respectively parallel to those on 42, thus having the same position-angles.

On plate 4 we see umbra and penumbra of a general circular outline; the intensely bright projection into the margin of the penumbra is shown in the depression in the north-west border. The breadth of the umbra in the direction of the north-easterly and south-westerly line is 14·2″, which equals, at the distance of sun on the 7th of August, 6,375 miles. Its width in the north-westerly and south-easterly line is 15·5″ or 6,960 miles.

Plate 42 shows the change of dimension and of form which took place in 1 h. 59 m. 33 s. The circular outlines of umbra and penumbra having changed to elliptical boundaries, the direction of the longer axis being north-west and south-east. The umbra has widened in this direction 4″, or 1,796 miles, and has, in the transverse direction, narrowed its breadth 5·25″ or 2,357 miles, while the outward projections of the umbra (which can be identified in plate 4), have become greatly lengthened.

The breadth of the umbra in north-east and south-west direction is 9·6″ or 4,310 miles; in the north-west and south-east line it is 19·6″ or 8,800.

After the drawings had been made with the camera-lucida, a micrometer plate was placed under the microscope without deranging the instrument, and the magnified image of hundredths of inches on the plate were marked on the drawings. This gave directly the value of the magnifying power used, and by computation, the value on the drawing, in fraction of an inch, of 1″ on the sun's disc.

8. *Observations on the application of photography to the determination of the times of contacts during the transits of Venus in* 1874 *and* 1882.

We here venture a few remarks, showing the peculiar value of photography in the observations of the transits of Venus.

It has been shown that the sun's image was photographed on the camera plate with an exposure of only $\frac{1}{500}$th of a second; and the duration of exposure for any other instrument can be determined with as great precision by the method which I employed.

The instant the mechanical movement exposes the plate, it also records the time of that exposure on a chronograph connected with a break-circuit clock, and thus we have an accurately delineated *figure* of the transit corresponding to a *time* marked on the face of the clock employed; and this correspondence of figure and time is unaffected with personal equation either of sight or of hearing. Now if the error and rate of the clock can be entirely freed from the personal equation of the observer who determined them, and if the longitude of the station be found by the coincidences of the beats of a sidereal clock with those of a break-circuit mean solar clock placed at the observatory of the first meridian, we have the most accurate means of obtaining the *absolute* times of contacts at the station of observation.

Thus we see how applicable will be photography to these observations; for the data of the solar parallax will be given either by observing *the absolute time* of the ingress or of the egress (which method is alone of value in the transit of 1874), or by determining *the duration* of the transit of Venus over the solar disc. The photographs are *permanent* phenomena on which we can repeat our measures at leisure, with every appliance of precision, while it is impossible to attain a similar degree with eye and ear, from the difficulty of micrometically measuring at a *precise* instant the dis-

tance of Venus from the sun's limb, and from the (recorded) distortions of Venus at contacts.

It will also be of great value to have a photographic record of the appearance of Venus at the contacts, for, *if* the disc of the planet then should appear on the plate to depart from a circle and have attachments to the sun's limb, these distortions can be measured and allowed for.

An idea may be formed of the apparent size of Venus during its transit of the sun's disc, from the fact that the umbra of the solar spot in the south-west quadrant is 15″ in diameter, and that Venus at transit will subtend an angle of about 70″; so that the planet would appear on the plate as a disc $4\frac{2}{3}$ times the diameter of this spot, or, as a disc of ·107 inch diameter on an image of the sun of 3 inches in diameter.

The negatives of these photographs I find from trial will stand a magnifying power of 50 under the micrometer, and as 1″ of arc will equal $\frac{1}{70}$th inch on a solar image of 3 inches diameter, we can, with the above mentioned power, divide a second into ten parts. This supposes, however, that the bisection by the micrometer thread is on a perfectly well defined point, and this does not exist in the outlines of any photograph, and especially is the limb of the sun indistinct on account of its shading, and of the manner in which the silver is deposited in the collodion film.

From actual experience in measurements under the micrometer, I find that we cannot, as yet, hope to make a bisection on the sun's limb closer than $\frac{1}{2}$ of a second. On the boundary of the umbra of a well defined solar spot, we can read to $\frac{1}{4}$ of a second, and from this I should think, that $\frac{3}{10}$ of a second might probably be attained as the limit in a reading on the limb of the image of Venus.

But with measures as close as these, and the tables of Venus brought to the accuracy which existing unreduced observations can give, we may reasonably hope for a determination of the solar parallax comporting with the most exact astronomical measures of this century.

The Lehigh University, Pa., 7th September, 1861.

SOLAR ECLIPSE OF AUGUST 7, 1869.

REPORT OF PROF. CHARLES F. HIMES, PH.D.

Prof. Morton:—

Dear Sir,—According to request, I make the following report of the section of the Photographic Corps organized by you and stationed at Ottumwa, Iowa, consisting of J. Zentmayer, J. C. Browne, E. Moelling, W. J. Baker, and myself.

The point of observation was finely located on a hill about a mile north-east of the city, in latitude 41° 2′, longitude 92° 23′ West of Greenwich, according to determinations of Professor Alexander, who happened to be located at the same place for astronomical observations.

On our arrival on Wednesday evening preceding the 7th, we found a very convenient shelter shed, with sliding roof and photographic room, erected under instructions from Professor Coffin.

The telescope was set next day upon a cross of timber firmly let in the earth. The clock work, not of very superior construction, was found to have become deranged by carriage, but fortunately the skill and experience of Mr. Zentmayer were available, and it was put in as good running order by him as it was susceptible of, otherwise we would have lost the opportunity for taking the totality negatives with a length of exposure sufficient to give the amount of detail and corona we obtained. It was deemed advisable, however, that Mr. Moelling should pay exclusive attention to the clock during the progress of the eclipse, in order to detect and correct any irregularity that might occur.

In the absence of any assistance from an astronomical party, the adjustment of the instrument and of the reticule for determining angles of position was mainly accomplished by Mr. Zentmayer, in a very satisfactory manner, in spite of the unfavorable weather preceding the evening of the 6th.

The morning of the 7th found the sky overcast, but gradually with a dry wind from the east, the clouds gave way, until at noon, not a trace of cloud or haze was to be seen. These few hours were improved by determining the actinic focus with great accuracy.

I placed the chronograph, a make-circuit one with two pens, in position, having connected one pen with the camera to register the exposure of the plates, and the other with a key upon which the seconds were to be tapped from a chronometer; but whilst it was found to act satisfactorily, having cause to fear that, by reason of the

fact that for want of sufficient force it had to be entrusted to volunteer parties, it might become deranged at a critical moment, I did not deem it advisable to trust our record to it alone, and immediately before the beginning of the eclipse, determined to make a record of the times from a chronometer kindly placed at my disposal by Professor Alexander, the correction for which, as given by him, will be found with the annexed schedule of negatives. I found it very easy to note the fraction of a second by the click of the exposure slide, warning having been given me before touching the trigger. I send this record because that made by the chronograph is not complete, and, perhaps, not reliable, as far as it goes, as the instrument became deranged during the progress of the eclipse. I did not find leisure, at the time, to examine and compare it, and, as I regarded the schedule of negatives complete without it, took the liberty to place it in the hands of Prof. Alexander, subject to your request, as he desired to examine it for the record of some of his astronomical observations which he had made upon it by means of the key of the seconds-tapper.

The photographic preparation was exclusively managed by Messrs. Browne and Baker, and the negatives obtained were photographically perfect. A statement by them of formulæ of Collodion, solutions, &c., will doubtless be made to you.

It was found necessary to increase the length of exposure by detaching two of the springs attached to the exposure-slide as the total phase was approached. The exposure during the partial phase I would estimate at from $\frac{1}{30}$th to $\frac{1}{50}$th of a second, with the aperture of the telescope reduced to two inches by a diaphragm placed over the objective. During totality, the full aperture was used, and exposures of six, twelve and sixteen seconds given, producing negatives of exquisite sharpness and detail, including a portion of the corona. The general plan of exposure was to obtain five negatives, if possible, near the contacts, and three near the beginning and end of totality, and at intervals of five and ten minutes during the other phases, and we have reason to be satisfied with the results. The one immediately preceding totality displays the limb of the sun beautifully cut up into Bailey's beads, and the one taken at the instant of the close of the total phase, received the first rays of the emerging sun, but is of interest as showing in this connection the red prominences. On this plan thirty-four excellent, accurately timed negatives were obtained, as given in annexed schedule, in

which D indicates diaphragm of two inches, F, full aperture; under *Length of Exposure*, under *Drop*, 1 indicates exposure slide with slit $\frac{1}{40}$th of inch wide; 2, with slit $\frac{1}{30}$th; 3, with slit $\frac{1}{20}$th, and 4, with circular aperture size of eye-piece. Under *Spring*, 1, 2, 3, denote that one, two or three springs were used upon the exposure slide.

The distribution by you of the prints from negatives of last year at Aden, aided much in regulating developments and exposure.

Whilst we all feel fully satisfied with the results of our efforts, the success of which has been so largely due to the thoroughness of preparation in all details, and the use made of the experience of previous parties by you, we confess with observers of this phenomenon, generally, that we feel that our present experience would have been of great value.

We were necessarily excluded from extended observations beyond our special work, bnt there are several notes made that may be of interest in this connection.

I had watched the approach of totality, anxious if possible to obtain a negative with Bailey's beads, and was surprised with the sudden transition to comparative darkness at the instant of totality, and the peculiar brilliancy with which the stars seemed to spring out without the long struggle through twilight.

The corona approached much more nearly in regularity the four-rayed form generally given, and which had always seemed idealized or conventional. The S. W. ray was, however, unequally subdivided with the smaller part toward the north. The whole seemed of a fibrous, slightly curled or twisted character, somewhat like a cirrus cloud, and of silvery whiteness. The prominences, especially the large one a little to the left of south, seemed at the first instant of a dazzling white, but after my attention had been diverted for a few moments, it appeared of a brilliant decided rose color, bordering on crimson, and remained of this color to the close. To Mr. Zentmayer, who was engaged at the camera and had used neither telescope nor screen, it appeared white, with a slightly roseate hue. To Mr. Moelling, under similar conditions, it appeared white throughout. Messrs. Brown and Baker who had a short glimpse of it from the door of the dark room, rather incline to the opinion that they were white.

During the progress of the eclipse, Mr. Zentmayer, who examined the ground glass of the camera from time to time to notice the posi-

PHILADELPHIA PHOTOGRAPHIC CORPS.

Record of the Times and Lengths of Exposures of the Photographic Plates exposed during Total Eclipse of the Sun, at Ottumwa, Iowa, August 7th, 1869, as noted by C. F. Himes. Greenwich Time. To accompany report to Prof. Henry Morton.

No.	Time of Exposure.	Length of Expo.		Aperture.	
		Drop.	Spring.		
1	9 h. 59 m. 30 s.	1	3	D	Lost.
2	10 h.	1	3	D	
3	10 h. 1 m. 5 s	1	3	D	
4	10 h. 2 m, 5 s. (within a second.)	1	3	D	
5	10 h. 3s	1	3	D	
6	10 h. 4 m. 42 s.	1	3	D	
7	10 h. 9 m. 55 s	1	3	D	
8	10 h. 14 m. 57 s. } Glass marked XI. Second quality. }	1	3	D	
9	10 h. 19 m. 57 s.	1	3	D	Lost.
10	10 h. 28 m. 55 s.	1	3	D	Lost.
11	10 h. 32 m. 50 s.	1	3	D	
12	10 h. 37 m. 28 s.	1	3	D	Lost.
13	10 h. 41 m. 41 s.	1	3	D	
14	10 h. 49 m. 22½ s.—glass 2d quality.	1	3	D	
15	10 h. 55 m 56 s.	1	1	D	
16	10 h. 56 m. 33½ s.	1	1	D	
17	10 h. 57 m. 36½ s.	1	1	F	Baily's Beads.
18	about 6 seconds	4		F	
19	Totality " 12 " } Exposure	4		F	
20	" 16 "	4		F	
21	11 h. 4 m. 15 s. close of tot. and after tot.	4		F	Fogged a little.
22	11 h. 6 m. 12 s.	1	1	D	
23	11 h. 6 m. 52 s.	1	3	D	
24	11 h. 7 m. 57½ s.	1	3	D	
25	11 h. 10 m. 6½ s.	1	3	D	
26	11 h. 16 m. 16½ s.	1	3	D	
27	11 h. 22 m, 45½ s.	1	3	D	
28	11 h. 29 m. 27 s.	1	3	D	
29	11 h. 37 m. 57½ s.	1	3	D	
30	11 h. 47 m. 58 s.	1	3	D	
31	11 h. 53 m. 7½ s.	1	3	D	
32	11 h. 53 m. 45 s.	1	3	D	
33	11 h. 54 m. 12½ s.	1	3	D	
34	11 h. 55 m. 12 s.	1	3	D	
35	11 h. 55 m. 40 s.	1	3	D	
36	11 h. 56 m. 10 s.	1	3	D	
37	11 h. 57 m. 58 s.	1	3	D	
38	11 h. 59 m. 55 s.	1	3	D	
39	11 h. 59 m. 7½ s. by chronometer of different rate used by Prof. Alexander, and exposure made at signal from him at this time.	1	3	D	

D denotes aperture of two inches in diaphragm on objective.
F denotes full aperture.
Drop 1 indicates drop with slit in slide one-fortieth of an inch wide.
Drop 4 indicates drop with circular aperture size of eye-piece.
Spring 1, 2, 3, indicates number of springs used on drop.

tion of the image of the sun, called my attention to an appearance of small luminous bodies like meteors crossing the dark image of the moon from cusp to cusp. Subsequently, they were seen to pass over the ground glass from outside of the field on to the image of the sun, where of course they were lost, always coming from the same side. We were led by this circumstance to regard them as most likely to be optical illusions, perhaps insects with transparent wings or bodies, but the fact that other observers report a shower of meteors between the moon and the earth, which seemed to be as far as I can gather from a hasty description, identical in appearance with the objects noticed by us, our observation may be of considerable value, especially as Mr. Zentmayer, who saw most of them, is disposed not to regard them as optical illusions, since they must have been caused by objects not less than 2,000 feet distant.

I cannot omit to mention the friendly manner in which we were treated by the authorities and citizens of Ottumwa.

Favored as we were with a sky free from cloud or haze, and a beautiful point of view, this phenomenon left an ineraseable impression upon our minds and hearts.

Dickinson College, August 1st, 1869.

Condensing Magnetism.—M. Jamin has communicated to the French Academy of Sciences a curious paper on a method of condensing magnetism similar to the condensation of electricity. He describes an apparatus made for him by M. Limet which consists of a horse-shoe magnet composed of ten bars of homogeneous steel bolted together, the two sides being covered with insulated wire connected with 50 Bunsen's elements. When magnetised this magnet will bear a weight of 300 kilogrammes at the armature. When this armature is placed in contact with one only of the steel bars the magnetism of the other nine is considerably diminished. Now, although the magnet was previously saturated with magnetism it is possible to make it take more, and bear 600 kilogramme. Another armature may be put on, so as to bear only on one of the component bars, and more magnetism can be condensed. M. Jamin has thus caused the magnet to carry 680 kilogrammes. This was done by applying five armatures; but as soon as they were detached the magnet returned to its primitive strength.

REPORT OF PROF. E. C. PICKERING, Ph. D.

Mt. Pleasant, Iowa, August 9th, 1869.

Prof. Henry Morton:—

Dear Sir:—The following experiments were conducted at the Brazelton House, in this town. Latitude 40° 57′; longitude 91° 38′. The room used was in the third story, and had an unobstructed view to the west.

The most important experiments during the partial phase were thermometric; for this purpose three delicate thermometers were used. An alcohol thermometer, A, divided to half degrees, and two filled with mercury, B and C, the latter having a blackened bulb. A was hung in the room, in the shade; B kept its case, so that its temperature was very nearly constant; and C was exposed directly to the sun's rays.

TABLE I.

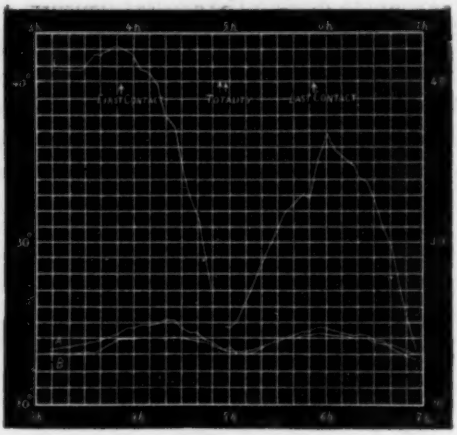
TIME.	A	B	C	TIME.	A	B	C
3 7	23·3	23·1	40·8	5 10	23·0	23·1	26·4
20	23·5	23·0	40·8	15	23·2	.....	27·6
29	23·7	23·2	40·8	20	23·4	23·4	28·7
36	23·8	23·2	41·7	25	23·6	23·6	29·6
40	23·9	23·4	41·7	30	23·8	....	31·0
50	24·3	24·0	42·2	35	24·0	24·0	32·0
55	24·7	24·0	42·0	40	24·3	24·0	32·4
4 0	24·7	24·0	41·8	45	24.4	24·2	33·1
5	24·9	24·0	40·8	50	24·5	24·2	32·9[a]
10	24·9	24·0	40·6	55	24·7	24·3	35·4
15	25·0	24·0	39·7	6 0	24·6	.....	36·9
20	25·3	24·0	38·0	5	24·5	24·2	35·8
25	25·2	24·1	37·4	18	24·2	.....	34·8
30	24·7	24·0	34·9	20	24·3	24·0	34·1
35	24·4	.....	33·0	25	24·2	24·0	33·9
40	24·3	.....	31·8	30	23·9	.....	32·9
45	23·9	23·8	28·6	35	23·8	.....	30·7
48	23·7	.....	27·2	40	23·5	23·7	29·7
57	23·3	23·3	24·8	45	23·2	.....	27·1
5 0	23·4	.....	24·7	50	.....	.....	25·2[b]
5	23 ?	.....	25 3	55	22·7	23·0	23·4[c]

[a] Shadow fell on C, causing the depression seen in the curve.
[b] Sun reaches cloud near horizon.
[c] Sun appears red through cloud.

Observations were made every five minutes after the eclipse began: at longer intervals before. The time is about a minute and a-half slower than the local time, or 56 m. 50 s. slower than Washington mean time. The temperatures are Centigrade, estimated to tenths of a degree.

The curves in the adjoining figure represent these results; Vertical distances give temperatures; Horizontal distances, times. They have also been drawn on a much larger scale, and the accidental errors in part eliminated by passing a curve through all the points; the difference was generally only a small fraction of a degree. The times were then computed at which 1, 2, 3, 4, &c. digits were eclipsed, and the corresponding temperatures obtained by interpolation.

Fig. 1.



THERMAL CURVES.

In the following table, the first column gives the number of digits eclipsed; negative numbers denoting distances between the two limbs. The second column gives the local time; the third, the temperature of A; the fourth, the estimated temperature, if there had been no eclipse. Of course, this is a very rough approximation, and was obtained by drawing a continuous curve through the beginning and end of the eclipse. It is only intended as a guide, and too much dependence must not be put on it. The last column gives the fraction of the sun's disc obscured.

By examining the third column of the above table, it will be seen that shortly before the eclipse the thermometer *rose*, attaining its maximum at the instant of contact, so that when three digits or 14 per cent. of the sun's disc was obscured, the temperature was about the same as before the eclipse. Again the thermometer continued to rise after the eclipse was over. These results were at first considered anamolous, but they were unexpectedly confirmed by the photographs of the sun taken at the same time. The increased brightness which these show along the moon's limb, prove

that the latter augments the actinic power of those parts of the sun's disc nearest it, and this renders the increase of heat also, very probable.

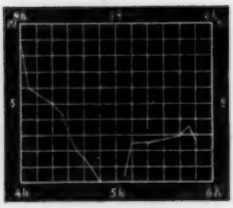
TABLE II.

Digits.	Time.	Temperature.		Obscur.	Digits.	Time.	Temperature.		Obscur.
		Real.	Assumed.				Real.	Assumed.	
— 8	3 8	40·8	.....	.....	12	4 59	24·7	39·5	1·000
— 7	13	40·8	.....	.....	11	5 4	25·1	39·3	·893
— 6	19	40·8	.....	.....	10	9	25·9	39·1	·789
— 5	25	40·8	.....	.....	9	14	27·1	38·9	·685
— 4	30	40·9	40·8	.....	8	19	28·2	38·7	·586
— 3	36	41·5	40·8	.....	7	24	29·3	38·5	·486
— 2	42	41·8	40·8	.....	6	28	30·1	38.3	·391
— 1	47	42·0	40·7	.....	5	32	31·3	38·0	·302
0	53	42·1	40·7	·0	4	37	32·1	37·8	·219
1	58	42·0	40·7	·029	3	41	32·8	37·6	.144
2	4 4	41·3	40·6	·079	2	45	33·5	37·3	·079
3	9	40·7	40·6	·144	1	50	34·4	36·9	·029
4	15	39·6	40·5	·219	0	54	35·2	36·6	·0
5	20	38·6	40·4	·302	— 1	58	36·1	36·3	.....
6	25	37·4	40·3	·391	— 2	6 2	36·1	....	.....
7	31	34·9	40·2	·486	— 3	7	35·7	....	.....
8	36	33·0	40·1	·586	— 4	11	35·3	....	.....
9	41	31·7	40·0	·685	— 5	15	35 0	....	.....
10	46	28·6	39·9	·789	— 6	19	34·4	....	.....
11	51	26·4	39·8	·893	— 7	23	33·9	....	.....
12	56	24·8	39·6	1·000	— 8	26	33·5	....	.....

Columns A and B, in the first table, show that the temperature of the air falls but slightly. As the instruments were in the room, they were protected from radiation. Their maxima occurred some time after the first contact, owing to the gradual warming of the room by the sun. In the last column of the second table, the discs of the sun and moon are supposed to be of the same size, as the latter, in reality, exceeded the former by about one twenty-fifth, the area obscured would be somewhat greater. The error, however, is only about 1 per cent. for eleven digits, and much less for other parts of the eclipse.

Actinometric experiments by the method of Bunsen and Roscoe were made, exposing pieces of sensitive paper every five minutes, for one minute to the sun, and then comparing them with a fixed scale. The series is enclosed, but the delicacy of the method does not appear to be sufficient to lead to important results.

Fig. 2.



Time.	Shade.	Time.	Shade.
40	85	50	1
5	60	5	8
20	50	10	25
25	45	20	25
30	30	35	26
35	20	40	30
40	15	59	25
45	8		

The Total Phase.

On the approach of totality the thermometric and actinometric experiments were given up, and the following observations made instead:—

General Observations.—A pocket-telescope magnifying about ten diameters was used. It was tied to the back of a chair by a piece of cloth, just tightly enough to make it remain in whatever position it was placed. This forms a convenient mounting, and by it the telescope can be moved steadily, and the sun or a star followed without difficulty.

The corona appeared as an irregular four-pointed star, with, of course, a black centre. Two of the rays were nearly vertical, and two horizontal, the left hand one pointing somewhat downward, while between it and the lower ray was a fifth smaller point. Its color was pure white: very different from the full moon, but resembling a cumulus cloud. Possibly the reddish tint noticed by many observers heretofore, may be a subjective effect due to the green color of surrounding trees or grass. Its texture resembled the ragged edge of a thunder cloud, or the crest of a wave torn by the wind. The striæ were not radial but spiral, as if the sun had been turned in such a way that the upper edge moved towards the east.

A very bright protuberance was seen on the lower edge of the sun; also, two others on the western side. The first, to the naked eye, appeared as much within as without the moon's limb, and, by irradiation, appeared to send rays some distance towards the centre. The sky presented the appearance it has during the morning twilight, the western horizon, however, being bright yellow.

I did not notice the sudden lowering of the temperature during

totality, although this was very perceptible to those in the open air; it would, therefore, seem that this is an effect mainly due to radiation.

After the reappearance of the sun, the corona remained visible for several seconds. Cocks in the neighborhood crowed repeatedly as the light returned.

The following star observations were made by Dr. C. Pearson, who also assisted in the actinometric observations. Mercury became visible at 4 h. 54 m., or two minutes before totality, and disappeared at 5 h. Venus was visible from 4 h. 51 m. to 5 h. 12 m., or twenty-one minutes.

Spectroscopic Observations.—A chemical spectroscope with one 60° prism was loaned me by Prof. Van Vleck, and was mounted in the way above described for the telescope. As no lens was placed in front of it, all the light which fell on the slit from a circle about 7° in diameter passed through the instrument. Turning it towards the sun before totality, the latter remained in the field. This is probably the best way to obtain the spectrum of the corona, as there is very little loss of light; the protuberances, however, are so small that their spectra would be faint, although the advantage of not having to move the instrument is a great one. The spectrum appeared to be continuous, with two or three bright lines, the brightest in the neighborhood of E, and the next near C; but as no dark solar lines were visible, these positions cannot be relied upon. The absence of the dark lines may be due to the want of brilliancy of the spectrum, although this was bright enough to have its upper and lower edges well defined.

Polarization.—The form of polariscope used was that adopted by Arago in his experiments on sky polarization. It consists of a tube about 20 inches long, and 2 inches in diameter, one end of which is closed by a double-image prism of Iceland spar, and the other by a plate of quartz. Looking through the former, we see two images of the latter, which, when the light is polarized, assume complementary tints. If, now, the corona was polarized in planes passing through the centre of the sun (as is generally admitted), when viewed through the polariscope, in one image the upper and lower parts should have appeared blue, and those on the right and left yellow; while in the second image these colors would be reversed, the yellow being above and below, and the blue on the sides. In reality, the two images were precisely alike, and both pure white,

but one was on a blue, the other on a yellow background. From this we infer that the corona was unpolarized, or, at least, that the polarization was too slight to be perceptible.

Although this does not prove that it shines by its own light, since polarization is produced only by specular, and not by diffuse reflection, yet these observations, and also those with the spectroscope, seem to render it probable. This view is also strengthened by the fact, that as the most distant portions are but about one hundredth part of the distance of the earth, they receive over ten thousand times as much heat per square foot.

The colored background mentioned above, shows that the sky, close to the corona, is strongly polarized, and since the tint is uniform on all sides of the sun, the plane of polarization is independent of the position of the latter—that is, the same on the sides, that it is above or below it. The most probable explanation of this most unexpected result is, that the earth beyond the limits of the shadow being strongly illuminated, acts as an independent source of light, and this being reflected by the air, becomes polarized in planes perpendicular to the horizon.

I am indebted to Mr. E. L. Wilson for the use of two Vogel's Photometers; and also to Messrs. Hover and Leisenring for assistance in the photographic experiments.

In conclusion, the new facts elicited may be summed up as follows:—An increase of heat and actinic power is observed in the beginning of the eclipse, caused by an increased brightness of the sun's disc near the moon's limb. The spectrum of the corona appears to be free from dark lines, but may contain two or three bright ones. Its striæ are spiral rather than radial, and its light is unpolarized. The sky adjoining it, however, reflecting light from the earth, shows strong signs of polarization.

Respectfully submitted,

EDWARD C. PICKERING

Solution of Uranium Salts not Fluorescent.—In the last number of *Les Mondes*, we find that M. Selhorst announces that the salts of uranium and cobalt do not fluoresce in Geissler tubes. We are glad to hear some authority announce this, having tried repeatedly to obtain the pnenomenon with uranium salts but without success, notwithstanding the statements of Du Moncel and Becquerel. —ED.

SPECTROSCOPIC NOTES.

By Prof. C. A. Young, of Dartmouth College.—No. 2.

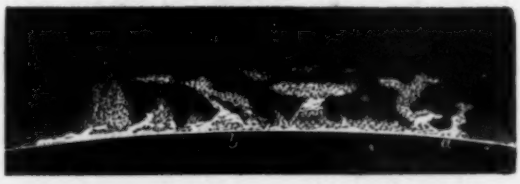
September 4th, 1869.—Prominences were noted on the sun's limb at 3, P. M., to-day, in the following positions, angles reckoned from North point to the East:—

1. $+70°$ to $+100°$, very straggling, not very bright.
2. $-10°$, large and diffuse.
3. $-90°$, small, but pretty bright.

September 13th, 1869.—The following protuberances were noted this P. M.

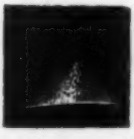
1. Between $+80°$ and $+110°$, a long straggling range of protuberances whose form was as in Fig. 1. I dare not profess any very extreme accuracy in the drawings, not being a practiced draughtsman, but the sketch gives a very fair idea of the number, form and arrangement of the immense cloudy mass, whose height was about 50″ and its length 330″ (22,500 miles by 1,350,000). The points *a* and *b* were very bright.

Fig. 1.



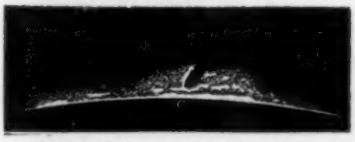
2. $+135°$ small, but very bright at the base, of this form: (Fig. 2.)

Fig. 2.



3. $-85°$ of this form (Fig. 3.)

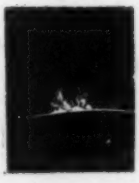
Fig. 3.



The dark spot, marked *c*, was very curious, reminding one strongly of the so-called fish-mouth in the nebula of Orion. I saw no change in it for 20 minutes. On the other hand, the first series mentioned were changing rapidly, so that, at 5 o'clock, the sketch, which was drawn at 2 was quite inapplicable, only the general features remaining unaltered.

4. $-128°$, about 20″ high, forked, thus:—

Fig. 4.



The structure was *cirrus* in every one but No. 3, which seemed more like a mass of cumulus.

To-day, for the first time, I saw b_1 reversed in the chromosphere when the slit was tangent to disc; 1474 was easy; the new line at 2602 cannot be detected as yet.

At 2·25, while examining the spectrum of a large group of spots near the sun's western limb, my attention was drawn to a peculiar double *knobbiness* of the F line (on the sun's disc, not at the edge,) represented by Fig. 1, *a* at the point *e*. In a very few